

TN
939
S33
v. 20
c. 1
ENG5

N.B.

REPORTS OF THE GEOLOGICAL SURVEY.

SPECIAL REPORTS ON THE MINERAL
RESOURCES OF GREAT BRITAIN.

NGI STORAGE

VOL. XX.—LEAD AND ZINC. THE MINING
DISTRICT OF NORTH CARDIGANSHIRE
AND WEST MONTGOMERYSHIRE. ✓

BY

O. T. JONES, M.A., D.Sc.,

PROFESSOR OF GEOLOGY AND MINERALOGY, VICTORIA UNIVERSITY,
MANCHESTER

(Late of the University College of Wales, Aberystwyth).

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.



LONDON:

PRINTED UNDER THE AUTHORITY OF HIS MAJESTY'S
STATIONERY OFFICE.

To be purchased from

E. STANFORD, LTD., 12, 13 and 14, LONG ACRE, LONDON, W.C.2;
W. & A. K. JOHNSTON, LTD., 2, ST. ANDREW SQUARE, EDINBURGH;
HODGES, FIGGIS & CO. LTD., 20, NASSAU STREET, and
17 and 18, FREDERICK STREET, DUBLIN;
or from any Agent for the sale of Ordnance Survey Maps; or through any
Bookseller, from the DIRECTOR GENERAL, ORDNANCE SURVEY,
SOUTHAMPTON.

1922.

Price 7s. Net

MEMOIRS OF THE GEOLOGICAL SURVEY.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

VOL. XX.—LEAD AND ZINC. THE MINING DISTRICT OF NORTH CARDIGANSHIRE AND WEST MONTGOMERYSHIRE.

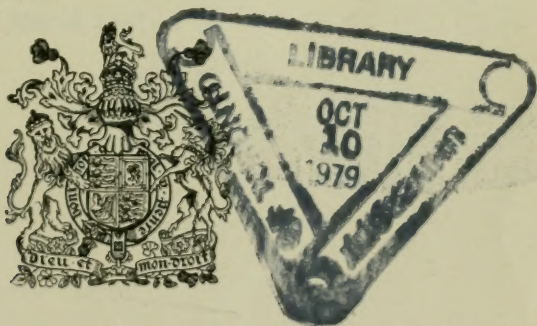
BY

O. T. JONES, M.A., D.Sc.,

PROFESSOR OF GEOLOGY AND MINERALOGY, VICTORIA UNIVERSITY,
MANCHESTER

(Late of the University College of Wales, Aberystwyth).

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.



LONDON:

PRINTED UNDER THE AUTHORITY OF HIS MAJESTY'S
STATIONERY OFFICE.

To be purchased from

E. STANFORD, LTD., 12, 13 and 14, LONG ACRE, LONDON, W.C.2;
W. & A. K. JOHNSTON, LTD., 2, ST. ANDREW SQUARE, EDINBURGH;
HODGES, FIGGIS & Co., LTD., 20, NASSAU STREET, and
17 and 18, FREDERICK STREET, DUBLIN;

or from any Agent for the sale of Ordnance Survey Maps; or through any
Bookseller, from the DIRECTOR GENERAL, ORDNANCE SURVEY,
SOUTHAMPTON.

1922.

Price 7s. Net.

MEMOIRS OF THE GEOLOGICAL SURVEY

SPECIAL REPORTS ON THE MINERAL
RESOURCES OF GREAT BRITAIN

THE GEOLOGICAL SURVEY OF GREAT BRITAIN
AND IRELAND

BY
THE GEOLOGICAL SURVEY OF GREAT BRITAIN
AND IRELAND



THE GEOLOGICAL SURVEY OF GREAT BRITAIN
AND IRELAND

PREFACE BY THE DIRECTOR.

The lead mines described in this Memoir have been extraordinarily productive, and it is by no means certain that large deposits may not yet be discovered in the area. The search for these must in any case be guided by a consideration of the relations of the lodes that have been worked in the past and the geological conditions under which they occur. Professor JONES has made a very thorough study of the general geology of this part of Wales, and is especially qualified to provide an account of the lodes in all their relationships. He has placed at the service of the Geological Survey the results of his investigations and has brought together a mass of information carefully sifted by personal familiarity with all the aspects of the subject. The descriptions of the mines, active and abandoned, show that all the practical problems involved have received very detailed consideration.

JOHN S. FLETT,
Director.

Geological Survey Office,
28, Jermyn Street,
London, S.W.1,
2nd March 1921.

PREFACE BY THE AUTHOR.

The area with which this Memoir deals includes portions of the One-Inch Sheets 163, 164, 178, 179. The One-Inch Sheet 163 was geologically surveyed on the 6-in. scale at various times between 1903 and 1916, but the investigation and mapping of the whole area from the mining point of view was carried out in the summer of 1917 and 1918, and I desire to acknowledge my thanks to the Council of the University College of Wales, Aberystwyth, for having released me as far as possible from my college duties during the time that the field-work was being done. I wish to thank also the following gentlemen who are connected with various mines for freely placing at my disposal information concerning the mines and for giving access to the workings and the plans :—

Mr. F. AHIER, late of Brynrafr Mine.
 Mr. JAMES ANDERSON, Bwlchglas.
 Mr. J. H. EVANS, Cwmystwyth.
 Mr. W. H. FRANCIS, Cwm Rheidol.
 Mr. W. MILLS, Llanidloes.
 Mr. R. R. NANCARROW, Ysbytty Ystwyth.
 Messrs. ONSLOW and MILLER, Llanidloes.
 Mr. W. H. PAULL, Llanbadarn.
 Mr. W. PLANT, Cwmmawr.
 Mr. W. RICHARDS, Penrhiw, Ystumtuen.
 Mr. JOHN WILLIAMS, Esgairmwyn.

To Capt. GEORGE PRYSE, late agent to the Gogerddan Estate, I am indebted for permission to use the mine records and plans in the Estate Office; to Mr. P. GRANT, Llanidloes, for access to plans belonging to Sir John Conroy, Bart.; and to Mr. W. W. WARE for facilitating my examination of the plans preserved in the Home Office. I desire also to tender my thanks to Mr. S. G. RUDLER, who, during his stay at Aberystwyth, generously assisted in extracting the statistics relating to the production of ore in this district.

To the Council of the Scientific and Industrial Research Department I am indebted for a grant enabling me to employ clerical assistance in the preparation of the Memoir.

Messrs. JOHN TAYLOR & SONS, 6, Queen Street Place, London, who carried on mining in the district for nearly three-quarters of a century, kindly allowed me the use of all their Cardiganshire plans, as well as the annual reports on the mines with which they were connected. These records proved of great value, as they furnished almost the sole information concerning the past workings of many of the largest mines in the district.

The history of the Lead Mines of Cardiganshire is treated so fully by R. HUNT in *Mem. Geol. Survey*, Vol. II., Pt. 2, 1848, that it is unnecessary to deal with it in this Memoir.

The University,
 Manchester,

O. T. JONES.

May 1920.

CONTENTS.

CHAPTER.	PAGE
I.—INTRODUCTION. STRUCTURE AND GEOLOGICAL HISTORY OF THE AREA - - - - -	1
II.—EAST-AND-WEST FAULTS AND LODES. LODES OF CARDIGANSHIRE - - - - -	20
III.—EAST-AND-WEST FAULTS AND LODES (<i>cont.</i>). LODES OF MONTGOMERYSHIRE - - - - -	36
IV.—DETAILED DESCRIPTION OF THE MINES. CARDIGANSHIRE MINES WITH A TOTAL OUTPUT, SINCE 1845, OF ABOUT 1,000 TONS OR OVER - - - - -	48
V.—DETAILED DESCRIPTION OF THE MINES (<i>cont.</i>). NOTES ON CARDIGANSHIRE MINES WITH A TOTAL OUTPUT OF LESS THAN 1,000 TONS - - - - -	129
VI.—DETAILED DESCRIPTION OF THE MINES (<i>cont.</i>). MONTGOMERYSHIRE MINES WITH A TOTAL OUTPUT OF ABOUT 1,000 TONS OR OVER - - - - -	150
VII.—DETAILED DESCRIPTION OF THE MINES (<i>cont.</i>). NOTES ON MONTGOMERYSHIRE MINES WITH A TOTAL OUTPUT OF LESS THAN 1,000 TONS - - - - -	167
VIII.—AGE AND ORIGIN OF THE ORES. INFLUENCE OF THE COUNTRY-ROCKS UPON THE LODES. ASSOCIATION OF MINERALS. THE PAST HISTORY OF THE INDUSTRY. FUTURE PROSPECTS OF THE AREA - - - - -	177
APPENDICES.—BIBLIOGRAPHY. ALPHABETICAL LIST OF MINES. LARGER MINES ARRANGED IN GEOGRAPHICAL ORDER FROM NORTH TO SOUTH. AMOUNT AND PROPORTION OF DIFFERENT ORES FROM THE VARIOUS FORMATIONS -	186
INDEX - - - - -	198

ILLUSTRATIONS.

MAP.

Coloured Geological Map, on the scale of 1 in. to 2 miles.

PLATES.

Facing page

I.—General Section of Formations	3
II.—Diagram showing type of folding	8
III.—Diagram to illustrate junctions of lodes	13
IV.—Geological Map of Esgairhir and Esgairfraith	20
V.—Geological Map of District near Blaenceulan	21
VI.—Network of lodes at Penpontpren	22
VII.—Map of lodes on Copper Hill, Cwmystwyth	32
VIII.—Geological Map of district around Geufron and Nantyricket	47
IX.—Longitudinal Section of Loveden Mine	48
X.—" " Brynrafr Mine	55
XI.—" " East Daren	65
XII.—" " South Daren	69
XIII.—" " Cwmerfin	74
XIV.—Section along lode from Goginan to Pengraigddu, showing relation of ore-bodies to the geological structure	78
XV.—Longitudinal Section of Cwmbrwyno Mine	86
XVI.—Transverse Section of lodes at Grogwynion	112
XVII.—Plan showing relation of Mitchell's lode to Comet and Kingside lodes, Cwmystwyth	115
XVIII.—Geological Map of the district near Pontrhydygroes	120
XIX.—Plan of Glogfawr showing relation of cross-course to the lode	124
XX.—Longitudinal Section of Llanerchyrour	151
XXI.—Geological Map of the Dylife and Dyfngwm districts	154
XXII.—" " district near Van Mine	157
XXIII.—Plan of Van flats	159
XXIV.—Chart showing annual output of Lead-Ore for Cardigan and Montgomery from 1845-1919	181
XXV.—" " price per ton of Lead and Lead-Ore from 1840 to 1919	182
XXVI.—" " output of the Lisburne group of mines	185

At end of Volume.

XXVII.—Relation of Goginan, Bwlch and Level Newydd lodes.

FIGURES IN THE TEXT.

PAGE

FIG. 1.—Diagram of lode splitting into two branches	14
FIG. 2.—Diagram to illustrate intersection of two lodes	15
FIG. 3.—Longitudinal Section of Mynyddgorddu	59
FIG. 4.—Transverse Section of lodes and Ystwyth fault at Cwmystwyth	114

LEAD AND ZINC. THE MINING DISTRICT OF NORTH CARDIGANSHIRE AND WEST MONTGOMERYSHIRE.

CHAPTER I.

INTRODUCTION.

From the mouth of the river Dovey to Machynlleth the limit of the area coloured on the map accompanying the memoir is the county boundary between Montgomery and Merioneth: thence to Caersws the Cambrian Railway forms a convenient limit, while south of this point one may regard the geological line formed by the base of the Wenlock formation as the extreme eastward limit of ore-occurrence within the area. In the neighbourhood of Tylweh, south of Llanidloes, a small portion of Radnorshire may be conveniently included, but from that point the county boundary between Cardigan and Radnor may serve as far as the hills north-east of Tregaron. The southern limit is an arbitrary line passing through that place and thence to the coast south of Aberystwyth. As regards a considerable area near the coast, there are no known ore-occurrences of any value, but it is advisable for various reasons to include the coast-line within the map. The majority of the mines lie near the centre of the region defined above, some in Cardigan-shire and some in Montgomeryshire. The region forms a compact mining-unit throughout which the character of the rocks, the nature of the lodes and their filling is fairly uniform. There is a notable absence of eruptive or intrusive rocks at the surface, and it is improbable that such rocks occur within a depth of some thousands of feet below the surface.

The geology of the region was investigated as early as 1833 and 1834 by Sedgwick,¹ who established the first classification of the strata. Most of the rocks within the area fall into his two groups, the Aberystwyth group and the Plynlimon group, which he regarded as being below the base of the Wenlock.

Between 1848 and 1850 the old-series maps of the Geological Survey, 56 N.W., 57 N.E., 59 S.E., 60 S.W., were issued, but about 1845 a horizontal section across the area had been published on the scale of 6 in. to the mile. On this section the nature of the folding of the rocks and the direction of the prevailing cleavage are beautifully represented. On the map the formations are referred mainly to the Bala or Caradoc group of the Lower Silurian, while the various areas of grit around Aberystwyth, Plynlimon and Cwmystwyth being supposed to represent a somewhat higher horizon are assigned to the Lower

¹ *Quart. Journ. Geol. Soc.*, Vol. iii, p. 133, 1847.

Llandovery formation, which was, at the date of the survey, also included in the Lower Silurian.

In 1881 Walter Keeping¹ communicated the results of his investigations on the area lying around Aberystwyth, Plynlimon and Rhayader, which was the first attempt, after Sedgwick, to reduce the rocks to a systematic order. He also announced the discovery in various localities of several species of fossils called graptolites which have been the basis of all subsequent researches on the succession of strata and the structure of the area.

Keeping established three groups in ascending order:—

- (1) The Aberystwyth grits.
- (2) The Metalliferous Slate group.
- (3) The Plynlimon group.

Groups (1) and (2) he united under the name of the Cardigan-shire group, while groups (2) and (3) constituted the Plynlimon group of Sedgwick. Keeping followed his predecessors in regarding the grits of Cwmystwyth and Plynlimon as the same and placed the Aberystwyth grits far below them. He recognised that a thickness of several thousand feet of rock was represented within the area.

It was not until many years later that careful investigation in several distinct localities revealed the true succession of the rocks and the distribution among them of the fossils (graptolites) which they contain. These investigations first made it possible to trace in detail various rock-groups, and to map the chief axes of folding and the more important displacements or faults which affect the strata.

The results of these researches are mainly embodied in papers by H. Lapworth² (Rhayader), Miss E. M. R. Wood³ (Tarannon district, near Llanbrynmair), O. T. Jones⁴ (Plynlimon and Pont-erwyd), O. T. Jones and W. J. Pugh⁵ (Machynlleth). The bearing of some of these investigations upon the general succession and structure of the region extending from Central Wales into Pembrokeshire were discussed in a paper published by the Author⁶ in 1912, wherein a small-scale map was given showing the distribution of the chief rock-groups and the principal axes of folding. It is clear from the papers mentioned above that the relative positions of the various grit-groups of North Cardigan-shire had been misinterpreted by the earlier geologists, for it has been proved that the Plynlimon and Cwmystwyth grits are separated by several thousands of feet of slaty rocks and that the Cwmystwyth grits are, in fact, equivalent to the Aberystwyth grits which are carried inland by the folding of the rocks. Furthermore, the Aberystwyth grits belong to the higher

¹ *Quart. Journ. Geol. Soc.*, Vol. xlii., p. 141, 1881.

² *Ib.*, Vol. lvi., p. 67, 1900.

³ *Ib.*, Vol. lxii., p. 644, 1906.

⁴ *Ib.*, Vol. lxv., p. 463, 1909.

⁵ *Ib.*, Vol. lxxi., p. 343, 1916.

⁶ *Ib.*, Vol. lxxviii., p. 328, 1912.

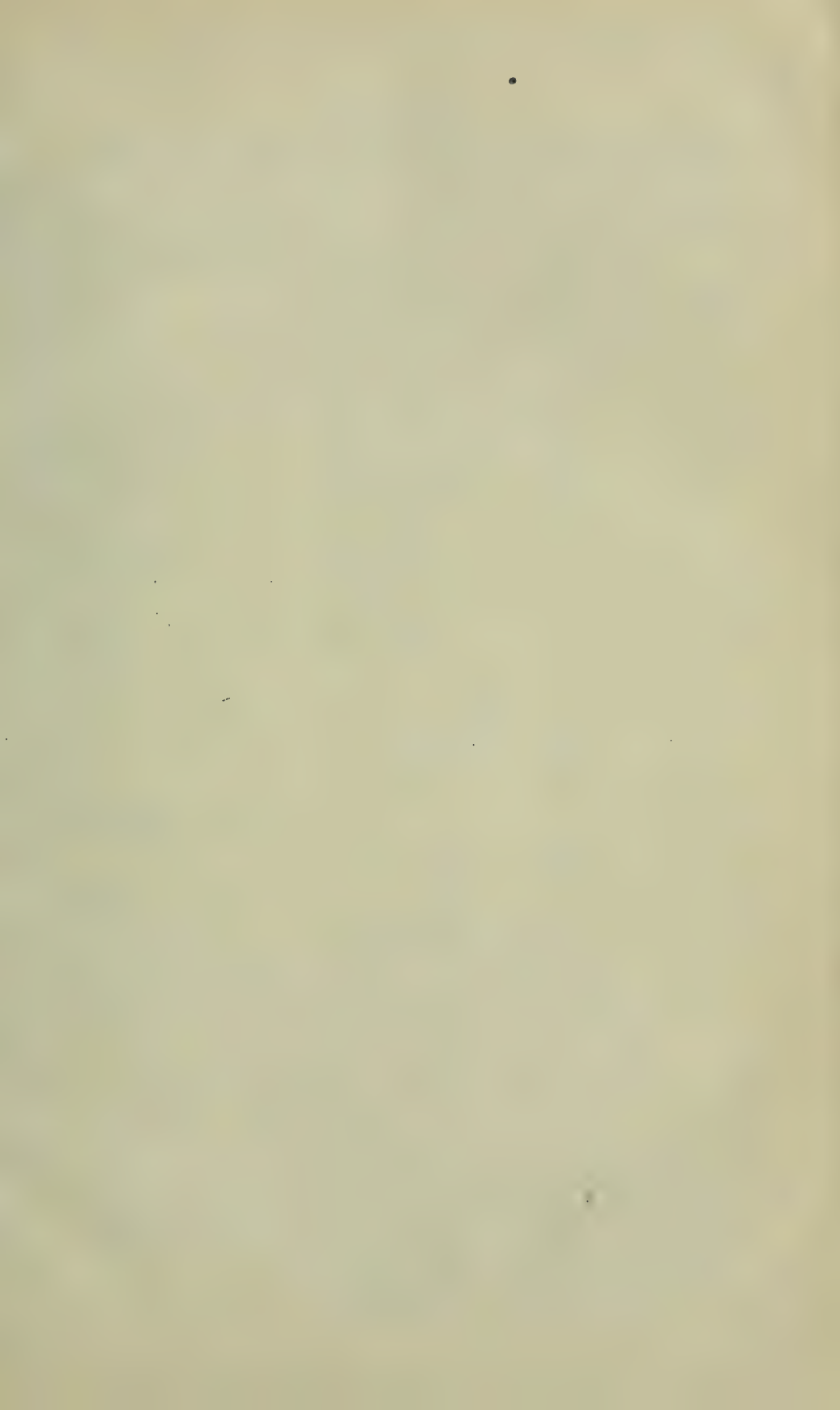
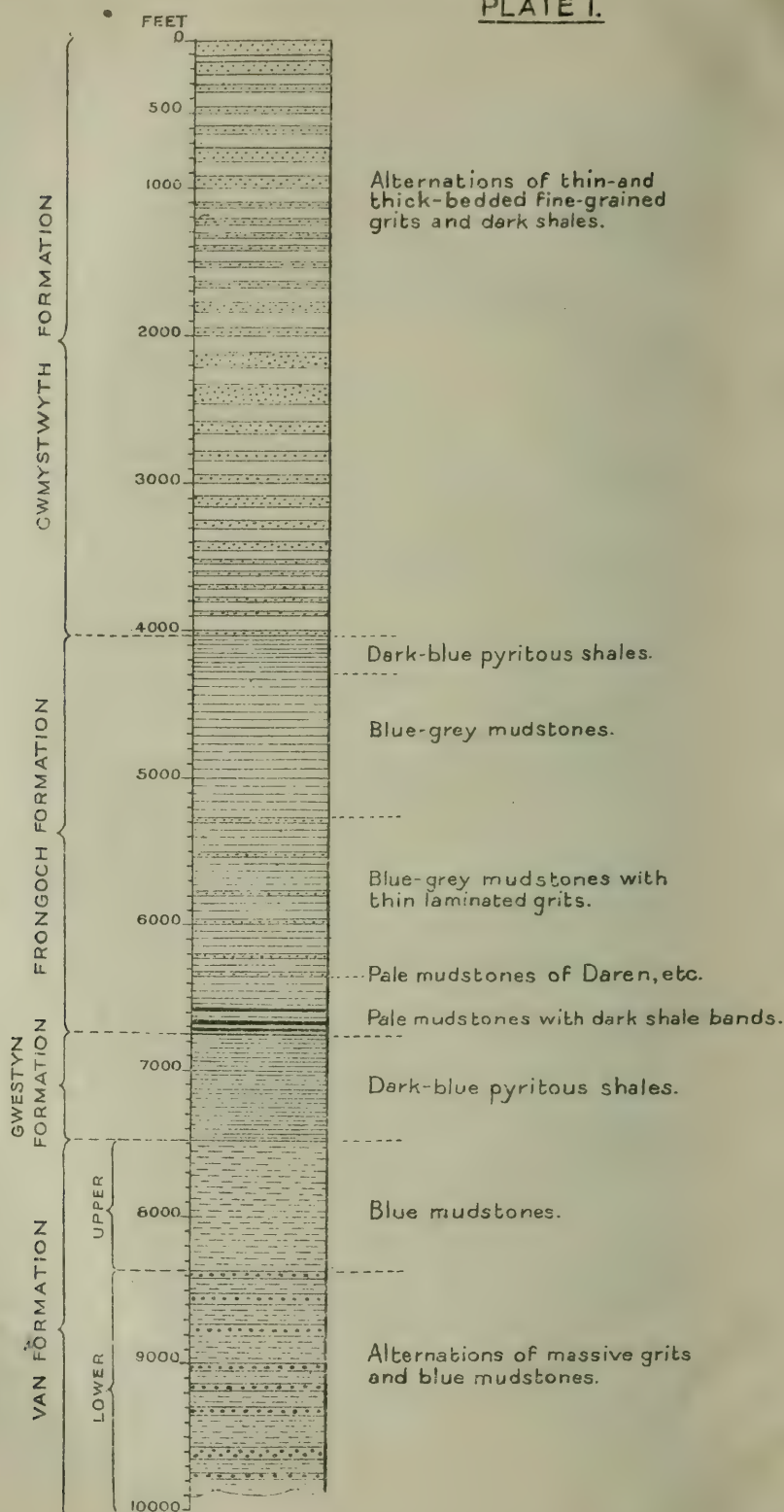


PLATE I.



GENERAL SECTION OF FORMATIONS.

or younger rock-groups of Central Wales while the Plynlimon grits lie among the older rocks. It has been shown, too, that although an enormous thickness of strata is represented within the area, only the Bala and the Llandovery formations are represented; the former being now assigned by geologists to the Ordovician System (roughly equivalent to the Lower Silurian) and the latter to the Silurian.

The detailed classifications established in the publications mentioned, wherein the rocks of different districts are named after places within each district, are not adapted to the purpose of a memoir dealing with the geology of the region from the mining point of view. A simpler grouping is, therefore, proposed wherein the principal rock-formations are named after some well-known mine which is situated mainly or wholly within the area which they occupy. It is believed that anyone who is acquainted with the formations as displayed in and around these mines will be able to apply this classification to the other mines both within and without the district, for the characters of the rocks are sufficiently distinct to make their identification readily possible.

The following classification is, therefore, used throughout the memoir, the formations being arranged in the order of their relative age, with the oldest at the bottom :—

Cwmystwyth formation (dark grits and shales).

Frongoch formation (grey and greenish shales, flags and mudstones).

Gwestyn formation (dark pyritous shales).

Van formation (dark mudstones with massive grey grits).

The relations of these formations and their average thicknesses are shown in Pl. I.

The Van Formation which occurs in and around the well-known Van mine may be divided into two parts. The Upper Van formation is found throughout most of the workings of that mine, and consists of rather soft dark mudstones which are affected by an irregular cleavage. They rarely contain iron-pyrite and exhibit little change of colour on weathering. Prolonged exposure at the surface usually causes them to break up into minute fragments and even to disintegrate into a clay.

The Lower Van formation was first met underground in the Van workings at about the 120-fm. level and has since been opened up throughout a large portion of the south-western end of the mine. The remarkable "flats," which are a peculiar feature of the mine, lie in a part of the formation. The rocks consist of massive beds of tough grey grit alternating with shales, which occur either in thin layers between the grits or in greater thickness separating groups of grit-beds. They are somewhat similar to the Upper Van shales and mudstones. The Lower Van grits are exposed at the surface over a considerable area on Van Hill and to the west, where they exhibit very clearly the

nature of the folding and displacements which have affected the district. The formation occupies a larger area around Plynlimon, both parts of it being represented; the Plynlimon mine at the surface lies in the upper division, but enters the lower division in depth. The grits are well displayed on the flanks of Plynlimon and on Drosgol to the west. West of Drosgol Brynryrafr mine and the old Hafan and Henfwlch mine also lie in this formation, both the upper and lower part occurring at various points in the workings.

A considerable area of the Van rocks occurs to the east of Talybont. No mine of any importance has been established there, but the Loveden mine on the roadside, about 4 miles north of Talybont, also lies in them. Between Van and Plynlimon the formation appears at Nantyricket on the Severn, where, in addition to the grits and mudstones, great beds of conglomerate may be seen on the hillside and in the bed of the river. The distribution of the formation as a whole is shown on the map accompanying the memoir. The average thickness may be estimated at about 2,400 ft., of which 900–1,000 ft. pertains to the upper part.

The Gwestyn Formation.—It is difficult to find a suitable name for these rocks, inasmuch as there are few mines of any importance within the area which they occupy. The Wye Valley mines, situated high up in the Wye Valley, offer the largest workings, but there is objection to using this name for rocks which only out-crop within a small area of the valley. Tyisaf mine, south of Llanbrynmair, lies wholly among them, but the name is commonly applied locally both to the older mine, Cae Conroy, near Tyisaf, and to another mine (Llanerchyrour) which lies in a higher formation: its use might, therefore, lead to confusion. For want of a better, the name of a disused mine on the course of the Van lode and about 3 miles west-south-west of Van is adopted.

The rocks consist of dark or almost black shales with only occasional thin beds of fine-grained sandstone. The most distinctive feature of the formation is the presence of abundant iron-pyrite, which is disseminated through the shales in the form of minute spheres or tiny globules, or as seams of crystals showing the common crystal outlines of the mineral. The presence of this material causes the rock to weather in brilliant yellow, orange, or red tints, the joint-faces, bedding-planes or cleavage-faces being often deeply stained. At other times the rock has been bleached partly or entirely to an ashy-grey tint; this effect may often be seen when it is exposed in roads and river-sections: the normal dark rock is traversed by numerous narrow pale stripes which usually follow the cleavage- and bedding-planes. In other cases bleached and rusty-weathering rocks may be observed side by side. Their characters are so distinctive that no difficulty should be found in identifying them. In their massive unweathered state, as in the underground workings of

a mine, it is sometimes difficult to distinguish this from other formations, but the presence of pyrite or the occurrence of faint stripes parallel to the bedding, and more particularly the presence of graptolites, should lead to a correct identification. From the map it is seen that the Gwestyn shales occupy a strip of varying width surrounding the outcrop of the Van rocks. The following localities indicate where the formation is well displayed or readily accessible: between Van Hill and Llawryglyn; between Van mine and East Van: on the main road between Steddfa Gurig and Dyffryn Castell: along the main road between Treddol and the Loveden mine; around Tyisaf or Cae Conroy mine and in Creigiau Esgairfochnant where it forms remarkable precipices on both sides of the ravine about 2 miles west-north-west of Dylife.

The width of the outcrop varies considerably from east to west and indicates a progressive decrease in the thickness of the formation in that direction. Around Van the thickness is about 1,300 ft.; west of Dylife about 1,000 ft.; near Ponterwyd about 750 ft., while around Glandovey or Machynlleth it does not exceed 350 ft.

The Frongoch Formation is named after the well-known mine which lies about 3 miles south-west of Devil's Bridge; and so far as is known, its base was not reached in the bottom workings at a depth of about 140 fms. below the surface. It consists of grey or greenish-grey shales, flags and tough mudstones; in parts of the formation there are numerous thin siliceous sandstone layers, but towards the top and also towards the base in the region north of the Ystwyth, bands of rusty-weathering dark shale occur which usually contain graptolites. In general each band of shale contains species of graptolites peculiar to itself, so that it is possible for a geologist who is familiar with these fossils to determine to which part of the formation any particular shale-band belongs. As will be indicated later it is of some importance to recognise those shale-bands that lie near the base so as to ascertain the probable depth of the underlying Gwestyn formation. There is, also, a well-marked group of pale greenish-grey mudstones which occupies a fairly constant position a few hundred feet above the base.

It is unnecessary to specify localities where the rocks may be seen. The majority of the Cardiganshire and West Montgomeryshire mines lie in them and in many of the former, as, for instance, Daren, South Daren, Cwmerfin, &c., the pale-green mudstones mentioned above are very noticeable in the surface excavations and in the refuse-heaps (hillocks or dumps).

South of the Ystwyth at Pontrhydygroes the rocks near the base of the formation undergo a remarkable change; the shales and mudstones pass southward into a group of massive grits of great thickness which form a prominent feature in the hills north of Ystrad Meurig and are found at the surface only in that neighbourhood.

The Cwmystwyth Formation is the highest in which ore has been discovered in any quantity and although it has a wide distribution Cwmystwyth is the only mine which lies within the formation. The rocks outcrop in a syncline which extends from about 4 miles north of Cwmystwyth along the hills east of Tregaron, where its axis coincides with the waterparting between the Teifi and the Towy valleys. The Aberystwyth grits, which are of the same age, form a strip along the coast, increasing in width southwards from near Borth and passing a few miles west of Tregaron; in the neighbourhood of that town the two outcrops approach to within about 6 miles of one another. The rocks consist of regular alternations of dark-grey speckled grits and smooth dark somewhat rusty-weathering shales; the grit-bands vary from an inch up to several feet in thickness and are usually distinguished by curious markings and convolutions on their under surfaces.

The centre of the syncline coincides with the uppermost branch of the River Ystwyth and the grit-formation is there overlain by a group of very pale greenish pasty shales (and in some localities purple shales). This group is of no interest from a mining point of view, and further consideration of it is omitted. The Cwmystwyth rocks outcrop also in the Tarannon tableland east of Llanbrynmair, and are overlain by similar pale shales associated with bands of purple shales. In that region the shale group is overlain by the basal beds of the Wenlock. The formation varies greatly in thickness in different localities. In the Tarannon area it has a maximum thickness of over 1,100 ft., but in the neighbourhood of Cwmystwyth it must be many thousands of feet. East of Llanidloes it has so changed in character that it can hardly be recognised between the Frongoch formation and the purple and green shales which underlie the Wenlock rocks from the neighbourhood of Llandinam southwards.

STRUCTURE AND GEOLOGICAL HISTORY OF THE AREA.

The present distribution of the formations is due in the first place to the earth-movements which have affected the district since the deposition of the rocks, and in the second place to prolonged denudation.

Earth-movements have produced two distinct structures, viz., folds and faults, but it is only some among the numerous faults that are of importance to the miner, inasmuch as the chief ore-occurrences are found along them. In view of the possibility that the rock-characters or the structure have some influence upon the distribution of the ore-bodies it is, however, necessary to pay some attention to the folding, as well as to the faults which do not themselves carry ore. The folding determines the position of the outcrops of the formations and the course of their boundary-lines, as well as the depth at which the rocks lie in different parts of the district. Thus the Van formation, which only appears at the surface in a few areas, nevertheless underlies

at varying depths the whole region, and from a study of the folding its depth can be estimated almost anywhere. The same applies to the Gwestyn formation which underlies the area covered by the Frongoch and Cwmystwyth rocks, but not that occupied by the Van formation which it overlies. It may thus be possible for certain rocks, although lying at a considerable depth, to exert an influence upon the distribution of ore near the surface.

The folding takes the form of a close succession of anticlines and synclines the axes of which range a few degrees east of north and west of south. The distance between the crests or troughs of adjoining major folds varies somewhat, but is commonly about a mile. If the crest of one of the anticlines could be exposed for a considerable length it would usually be found to slope either north or south, thus indicating that the folds are of the type known as pitching folds. To this is due the zig-zag course of the base of the Gwestyn and Frongoch formations. If the base of the Cwmystwyth rocks had been inserted on the map, its course would be similar in character. The pitch changes its direction along a line drawn from Van through Plynlimon to Hafan and thence to the Dovey estuary near the Loveden mine, and from this fact results the oval outcrop of the Van formation and the closed ring of Gwestyn rocks, which is so characteristic a feature of the geological map of the region. The direction of the axes of folding is clearly indicated by the elongated anticlinal outcrop of the Van formation at Brynmawr, about 3 miles west of Van; the anticline which ranges through Plynlimon Cwm Biga: the syncline immediately to the west of it which ranges from Cerig-yrwyn in the south to Brynrywyn in the north: the anticline of Cefnyresgair north of Brynryrafr mine; the anticline of Cerig yr Hafan and others. The dip of the beds east or west on each side of the axis is commonly between 45° and 60° , but in some cases it is less than this and in others the beds may become vertical. The pitch of the folds, or in other words, the dip along the crest of an anticline or the trough of a syncline is usually from 10° to 20° , *i.e.*, between about 1 in 6 and 1 in 3: this is, in general, the rate at which the Gwestyn rocks dive northward or southward below the overlying Frongoch formation, and from it we gain some indication of the depth at which those rocks may be encountered in the area lying outside their outcrop. In addition to these relatively large folds, the influence of which on the course of the geological boundary-lines is evident on a small-scale map, the rocks are affected by smaller folds in which the distance from crest to crest is only a few feet. Such small folds can be shown only on a very detailed map, but their effects are precisely similar in character to those of the larger folds; they may often be observed in quarries and road-surfaces or in adits and other mine workings. The existence of the type of folding described above proves that after the deposition of the rocks the district has suffered severe compression by earth-forces acting from west to east and east to west, *i.e.*, at right

angles to the axes of folding, whereby the original horizontal strata have been sharply crumpled or corrugated. The effect of such folding on the form of the outcrop is illustrated in Pl. II., where the single-barbed arrows indicate the pitch in the direction of the anticlinal axes C.D. or the synclinal axes E.F., and the double-barbed arrows indicate the dip of the rocks. The line A.B. is that along which the pitch changes its direction. The sections along each of these lines are given below. Another result of the same severe pressure is the cleavage-structure which is so prevalent throughout the area; in some localities workable slates have been produced, in others the structure is less perfect, but almost everywhere the finer-grained rocks will split more readily in the direction of cleavage than in the direction of the original bedding. The cleavage-planes dip with some regularity at high angles to the west-north-west.

The Faults.—A glance at the map reveals the existence of a large number of faults which interrupt the continuity of the geological boundary-lines or cause breaks in the normal succession of the rocks. A much larger number of faults has been recognised and mapped, but it is not possible to insert all of them upon a small-scale map.

The faults may be grouped into two main classes :—

- (1) North-and-south faults.
- (2) East-and-west faults.

Faults of each class may, however, depart considerably from these directions.

The North-and-South Faults.—The trend of these is closely related to that of the axes of folding; the majority of them lie, therefore, a few degrees east of north and west of south. They are thus, approximately, strike-faults and have the effect in different cases of repeating a part of the succession, or of cutting out a certain thickness of rocks. Some of them can be proved to be reversed faults or overthrusts with a hade or inclination towards the upthrow side, and the majority are probably of this character; others, again, are known to be normal faults hading to the downthrow. The close parallelism between them and the axes of folding suggests that they originated at the same period. In every region which has undergone severe compression, the rocks have yielded partly by folding, partly by overthrust faulting, and partly by the development of cleavage; in this district all these structures are associated.

Such faults are often met in underground workings, and where they are sufficiently conspicuous to attract notice they are in some cases termed clay-joints; in others, cross-courses, especially where they resemble a lode. Their relation to the lodes is discussed on another page. As a general rule, they are barren, but in some cases they carry ore in the neighbourhood of productive lodes. Some examples of this class of faults may be

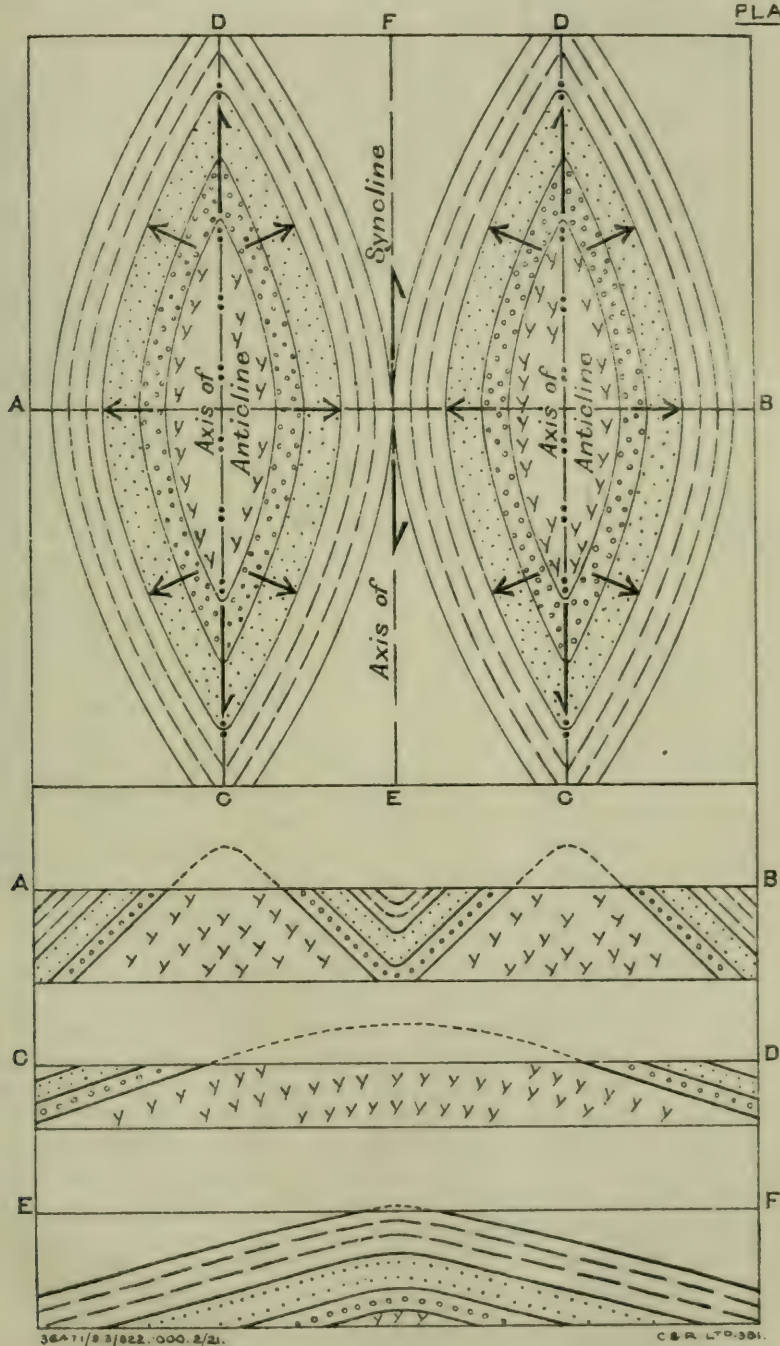


DIAGRAM SHOWING TYPE OF FOLDING.

noted. Near the entrance to Lodge Park, north of Taliesin, a great mass of crushed rock visible on the hillside marks the position of a strike-fault which carries down some part of the Frongoch formation against beds which are not far above the base of the Gwestyn shales. It has, therefore, a downthrow to the west of considerable magnitude. The course of the fault northward is indicated by the long straight depression along which the road has been carried. Southward there is no direct evidence of it, but it probably follows the foot of the hills overlooking the marshy flat of Cors Fochno.

Less than a mile to the east is another fault with a westerly downthrow, which can be traced from Pensarn Chapel, three quarters of a mile east of Taliesin, to near Glandovey Castle, its course being indicated almost all the way by a marked depression.

East of Blaenceulan mine a strike-fault with easterly downthrow is responsible for some shattered rock and vein-quartz exposed in the stream near the adit-mouth. From this point the fault can be traced for some distance northward and southward in the direction of Bwlchglas mine. In the underground workings of that mine several north-and-south faults or cross-courses have been met to the west of the adits; two of these are inclined to the east at about 50° and one to the west at about the same angle. Although it is believed that they produce a slight displacement of the lodes the effect is too small to afford a reliable means of determining whether they are normal or reversed faults.

Near Brynrafr mine a strike-fault with westerly downthrow lets down a narrow wedge of the Gwestyn formation into the Van rocks and another fault having the same direction and inclination was met in the workings some distance to the east and appears to have interrupted the lode. Near the Llynant valley several faults of this kind were proved to be overthrusts with an easterly downthrow and inclined to the west at 40° to 60° from the horizontal. In that district the strata have, therefore, been pushed over from the west towards the east.¹ At the old mine of Nantyreira (Snowbrook) a north-and-south fissure traversing the massive grits of the Lower Van formation has been worked for lead-ore, and there are indications that some of the workings are very ancient. On the line of this fissure a strong cross-course traverses the underground workings of Nantiago mine; it is met in the 50-fm. level at about 22 fms. west of the pumping-shaft where it dips to the east at 75° . The same fracture crosses the geological boundaries farther south and throws the rocks down on the east side; this cross-course is, therefore, a normal fault. What is probably the same fault displaces the base of the Gwestyn formation about $2\frac{1}{2}$ miles north of Nantyreira and there also it has a downthrow to the east. The fault is exposed in the stream bank near by, and as its plane is inclined to the downthrow side it must be a

¹ O. T. Jones and W. J. Pugh, *Quart. Journ. Geol. Soc.*, Vol. lxxviii, p. 369.

normal fault. There is little doubt that this fracture is continuous for a distance of at least 4 or 5 miles and maintains throughout a constant direction and downthrow. It has, however, only yielded ore at one point, and so far as is known has not produced much.

Along the centre of the Pennant valley, south of Llanbrynmair, a powerful fault with easterly downthrow brings the Gwestyn rocks against a high part of the Frongoch formation. This fault can be traced by its geological effects for several miles south of that valley, but dies away in that direction. A great cross-course met in the underground workings of Glogfach and Glogfawr is described in connection with those mines. The influence of these faults must be taken into account in estimating the depth to a given formation at various points.

The East-and-West Faults.—From the economic point of view these faults are the most important, inasmuch as the mineral deposits of the region are associated with them. It was not until the various groups of rocks had been recognised and mapped that it was possible to obtain definite proof of the nature of the fissures in which the ores are found. It is now clear that the metalliferous lodes are almost restricted to faults of this class, but the conception of a lode in the mining sense is in general somewhat narrower than the geological conception of the fault of which it is a part. It is not improbable that if the true relation of the lodes to the faults which traverse the country-rocks had been correctly appreciated, various mistakes in the mining explorations would have been avoided and a greater economy in the working of the mines would have resulted. If these faults are compared one with another they exhibit a wide diversity of character, but it is not possible to establish any rigid subdivisions. At one extreme there are major faults with a downthrow of several hundreds of feet; these usually have a well-defined footwall and sometimes, though less commonly, a clearly-marked hanging-wall; outside these walls the country-rocks are comparatively free from fractures. The width of the fault between its hanging-wall and footwall is usually 20 or 30 ft., but may occasionally be as much as 100 to 120 ft. There is rarely any difficulty in tracing the footwall of the fault horizontally or vertically, but in the shattered belt between the two walls it is not uncommon to find one or more well-defined "false walls" which have repeatedly been mistaken for the true footwall or hanging-wall, where the precaution has not been adopted of testing the fault to its full width. These faults are distinguished also by a considerable hade or underlie which varies from 25° to 35° from the vertical, but may be as much as 45° . The fault-filling consists of angular fragments of the adjoining country-rocks, cemented together by quartz or less commonly calcite; in other cases the place of these is largely taken by galena, blende, iron-pyrite, marcasite or copper-pyrite. Rock-

masses of very large size are sometimes included between the walls of the fault; where such a rock occurs within a body of ore it is termed a "horse" by the miners. In many cases a fine clay fills the cavities between the rock-fragments and is commonly found along the true as well as the false walls of the fault. This is usually known as flucan, and is sometimes the only filling of a fault-fissure.

Briefly the chief characters of these major faults are their great downthrow, their considerable hade and width and their persistence, both horizontally and vertically; although the majority of them have a downthrow to the south, there are cases of faults agreeing in all respects with the above description which have a downthrow in the opposite direction.

At the other extreme are faults which have produced only an insignificant displacement of the adjoining rocks and are scarcely to be distinguished from powerful master-joints. These minor faults which have a width of a few inches to a few feet, often lack well-defined walls, and are in consequence difficult to trace for any distance. The fault-filling is similar to that of the major faults. As a rule these fissures have a small hade, being in one place inclined a few degrees in one direction and often in another place in the opposite direction. Their characteristics are, therefore, a small width and displacement, a small hade, inconstant both in amount and direction, and impersistency. From their similarity to joints they may be termed joint-faults.

There are, however, faults which exhibit characteristics intermediate between those noted above as belonging to the one type or the other. A fairly common type consists of a close-set system of subparallel fractures filled with veins of crystallized quartz and ore; the rock between them being strongly shattered and veined and occasionally broken up into angular pieces (Llanerchyrour); the whole shatter-belt is mineralized, but, as a rule, it is attended by little displacement of the country-rocks. Although the belt may, in places, be of considerable width, at no great distance it may narrow down to a fissure a few inches wide, filled with triturated rock and vein-quartz, or it may even cease to exist (Evans's lode, Bwlchglas).

The walls or planes of the fault are frequently smooth, striated or "slickensided"; the striations are more often inclined than vertical and indicate that the vertical displacement of the adjoining rocks was accompanied by some movement in a horizontal direction. In a number of cases the striations dip to the west at an angle of 45° to 60° and when a large area of a fault-plane has been exposed in mining operations the striations generally preserve a constant direction.

The Relation of the Lodes to the East-and-West Faults.—Any fissure is termed a lode if it shows evidence of mineralization by the occurrence of minerals such as quartz, calcite or dolomite or of gossan, even though no ore may have been discovered. The characters relied on for the identification of a fissure as

a lode is, therefore, the presence of more or less defined walls and evidence of such mineralization as is found by experience to be associated with the ore-bodies of the district. There is always the expectation that a fissure exhibiting these characters may at some point or other be found to carry ore in productive quantities, and the "promise" of a lode is estimated by the nature of its walls and the degree of mineralization which it exhibits. If, at the same time, it has been proved to carry ore even in small quantities or "spots," it is considered worthy of trial at a depth by sinking a shaft or driving an adit. So far as these simple fissures go there is no great difference between the mining conception of the fissure as a lode and the geological conception of it as a fault, and the lodes of the district, almost without exception, are faults of the east-and-west system. In the mining sense the term "fault" is commonly restricted to something which interrupts or displaces the lode, and it is not generally realised that the lodes themselves are true normal faults, which have produced more or less displacement of the country-rocks, throwing the strata in the hanging-wall to a lower level than their continuation in the footwall. In fact a lode is but a mineralized fault or part of a fault. As the east-and-west faults of this region, with the exception of the Llyfnant and Ystwyth faults, appear to be of the same general age any one of them is potentially a lode, though experience has shown that many of them carry no ore, the productive lodes being for some reason restricted to certain areas. Thus a considerable number of east-and-west faults have been traced in the district south of Glandovey and north of the Llyfnant valley, but up to the present none of them have been found to carry ore in any appreciable quantity.

It is where the fault is of considerable width that a difference arises between the geological and mining usage. The fault comprises the whole width of shattered rock included between the sound country-rocks on either side. Within this width one or more mineralized belts, either productive or not, may occur, and may keep, for some distance, a constant position relatively to the bounding walls of the fault. To the miner these are distinct lodes and are named accordingly, though they are all contained within the limits of a single fault. If these mineralized or productive belts did really maintain themselves distinct so that they occupied always the same position within the fault little harm would ensue from this conception, but experience has shown that this is far from being the case. As was observed by Smyth: "When a mineral deposit is of considerable width the ore portion has often a tendency to run in irregular sheets, sometimes near the 'lying,' at others near the 'hanging wall'; and where one such stripe has been followed till it seems to have wedged out, the commencement of a second has been found by turning away towards the opposite side."¹

¹ *Mem. Geol. Surv.*, Vol. ii, pt. 2, 1848, p. 663.

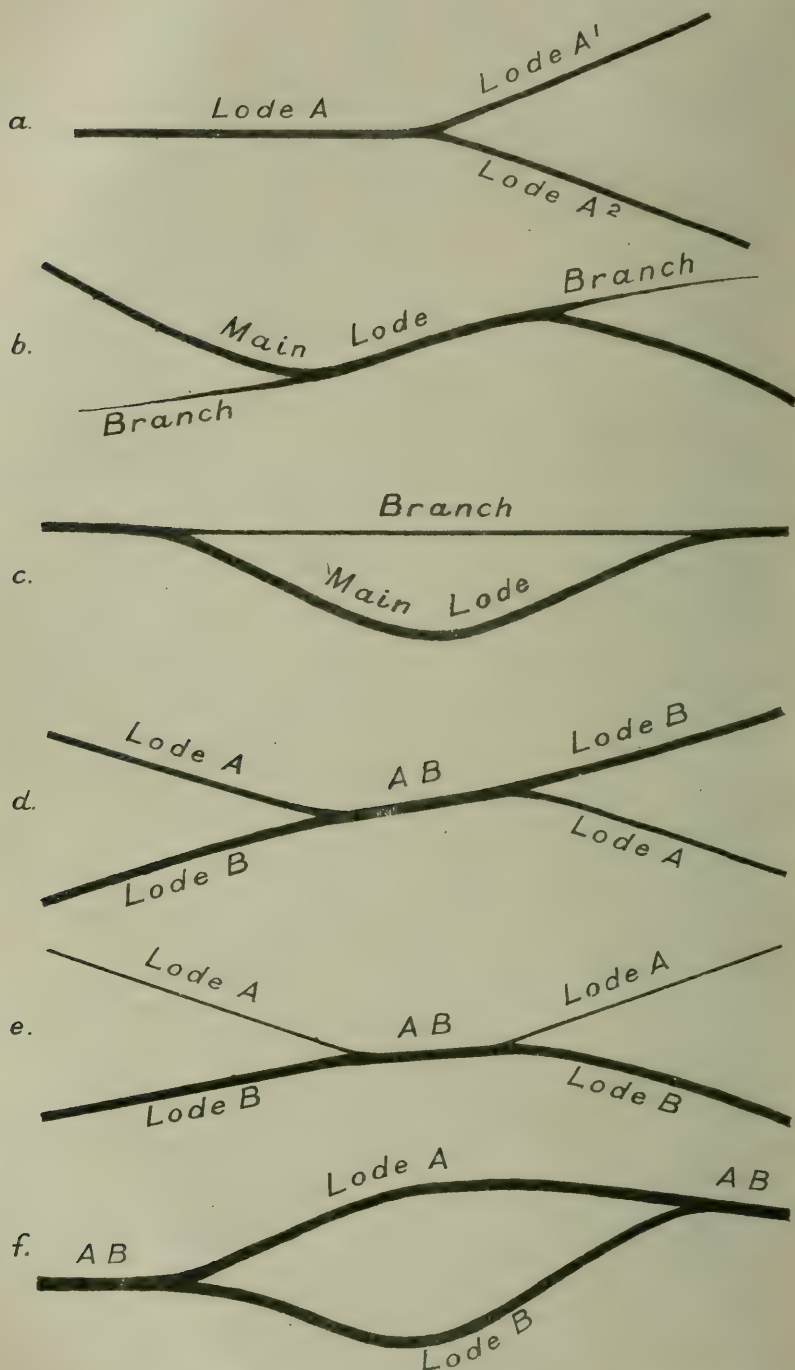


DIAGRAM TO ILLUSTRATE JUNCTIONS OF LODES.

To regard these inconstant "stripes" of ore matter contained within a fault as separate and distinct lodes is therefore not only misleading, in that it suggests the existence within the region of a larger number of lodes than is justifiable, but has also led to grave errors in the past, as the history of several mines in the district proves. Thus it is recorded that at Esgairhir which has been worked for centuries "each successive party" found "great courses of ore left standing by the side of former workings."¹

The Esgairhir fault is of considerable width and the ore was found in short though rich bunches; if, during the tenure of any Company, the precaution had been taken of testing at intervals the fault to its full width, instead of following each supposed lode to its termination and then abandoning the mine as exhausted the remaining bunches standing to one side or other would in all probability have been discovered and profitably extracted. It is not uncommon to see levels driven for long distances in these wide faults without a single cross-cut right or left. When a cross-cut was driven out of one of these levels some years ago in the Penrhiw mine, a rich bunch of lead-ore was discovered running parallel to the level and only a few yards distant from it. The history of the early explorations of Logaulas affords another instance of the insufficient testing of a wide fault. The exploration of such faults should therefore always be carried to their extreme limits, and to this end it would be better to regard the lode as embracing the whole width of the fault, the ore-bodies contained within it being designated branches, veins, or strings.

Throughout this Memoir these east-and-west fractures will be referred to as faults in the generic sense, where there is no evidence that ore has been obtained from them at any point. Where they have proved productive, even if at only one or two places, they will be termed lodes. On the general map, where both classes are indicated alike, the proved lodes can easily be distinguished by the occurrence of mines on their outcrop.

Intersection of Lodes.—In this district, as in others, great importance is attached to the intersection of one or more lodes at an acute angle. It is generally believed that the ore-bodies are enriched or more concentrated in the neighbourhood of such intersections, both in the horizontal and vertical direction as is noted by Smyth (p. 666). The large number of possible cases of such intersections can be reduced to a few general types, each having special characteristics (Pl. III).

1. *The Splitting of a Single Lode.*—It is not uncommon to find a lode, which so far as can be observed is a single fault-fracture, suddenly breaking up or splitting into two or more branches which pursue thereafter separate courses. Each of these may persist for a long distance and may display differences not only in direction but also in hade, width, displacement, and

¹ A. Francis, "History of Cardiganshire Mines," p. 9.

even lode-filling from the parent-lode (Fig. 1). A good example is afforded by the Esgairhir lode which, in going west from that mine, splits up more than once, the single fault of large displace-

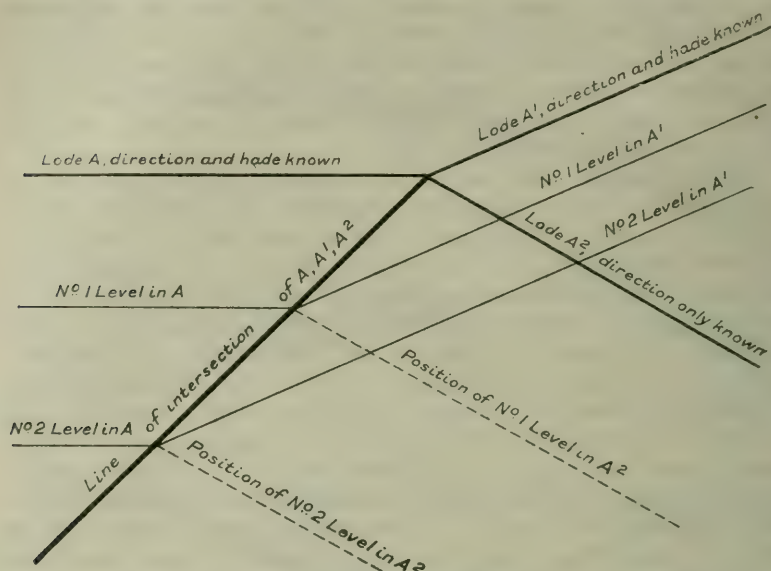


FIG. 1.—DIAGRAM OF LODI SPLITTING INTO TWO BRANCHES.

ment being ultimately resolved into four or five separate faults each of small effect (*see* Pl. V, facing p. 21). In the case of a simple split the direction of the line of intersection is theoretically determined by the relative direction and hade of any two out of the three lodes, the direction or the hade (but not both) of the third being determined when the elements of the other two are known; if the direction or hade of the third is known the other element can be found geometrically. The position and direction of the line of intersection as determined geometrically often agrees closely with the result of underground exploration though it is not always possible to locate the split exactly owing to the shattering of the rocks which is usually found in its neighbourhood, and which, probably, accounts in some cases for the local enrichment of ore-bodies. Occasionally an apparently simple lode proves when seen in clear section really to consist of two parallel lodes close together, each having its distinct footwall and hanging-wall and separated by a narrow bar of country-rock. Each of these lodes may at any point proceed independently of the other and thus give the appearance of a splitting lode. Such a case is illustrated in the Dyfnwgwm valley (*see* p. 38 and Pl. XXI). An analogous case to this is afforded by many lodes which pursue an undulating course, swinging rather abruptly, now in one direction, now in the other. Nearly all the larger lodes and faults of the district exhibit this tendency; in none is it more striking than in the Hafan lode. It is often noted that at a bend or curve of the main lode a

branch is given off from the convex side of the curve in such a way that its direction is continuous with the lode in one arm or other of the bend. This occurs so systematically that it can hardly be regarded as an accident.

This case differs from that previously noted in several respects. The main lode preserves its displacement and usually its other characters unchanged after giving off the branch; the branch itself is of small effect and is most marked in the neighbourhood of its origin. As a rule, the fissure tends to close up and disappear when traced away from that point; in these various ways it shows itself clearly dependent upon the major fracture. Numerous examples of this type will be mentioned in connection with individual faults or lodes.

A third case may be observed occasionally in strongly undulating lodes and may be regarded as a double example of the type last described. Branches given off at two points of the major fracture unite to form a chord stretching across the curve of the main lode (near Bwlchglas). The principal displacement is associated with the main lode and in this respect is distinguished from a somewhat analogous example from Cwmystwyth (p. 31). The relation in depth of the intersection of the branch and main lode to the direction and hade of the parent fracture and its offspring is similar to that in the first case.

2. *The Intersection of Two Independent Lodes.*—It happens occasionally that two lodes having different characteristics and inclined to one another at a small angle meet and cross. In such cases they usually run together for some distance before separating (Fig. 2). A good example is that of the Comet and

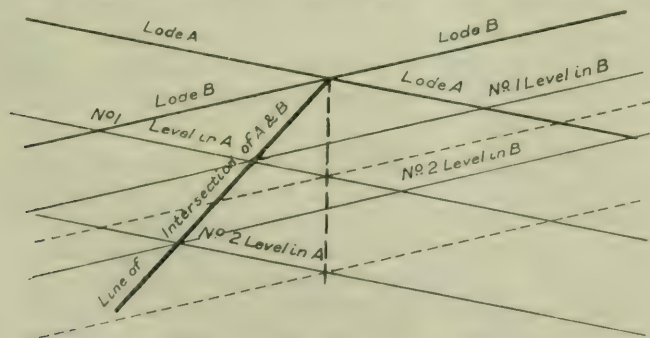


FIG. 2.—DIAGRAM TO ILLUSTRATE INTERSECTION OF TWO LODES.

Kingside lodes in Graigfawr (or the Great Rock), Cwmystwyth. West of this point the Kingside is several yards south of the Comet, but east of it that lode has passed through the Comet and appears on the north, thereafter diverging widely from it. The intersection of the footwalls of the two lodes was, until a few years ago, visible in the face of Graigfawr, but that part has since been removed by mining operations. The direction of the line of intersection in such cases depends upon the relative hade of the two lodes; if their hade are equal the line of intersection

bisects in plan the angle included between the strikes or level courses of the lodes (if the lodes are in the same direction the obtuse angle is bisected, if they are in opposite directions the acute angle), while if they are different the junction lies nearer the outcrop of the lode with the smaller hade or greater inclination from the horizontal; these two conditions are illustrated in Fig. 5. If, as is usual, the two lodes run in company for some distance, their junction is a plane bounded by the surface of the ground and the lines of intersection drawn downwards from the point of union and the point of departure. The Van lode may also offer an instance of a simple intersection of two lodes though up to the present this has not been proved (see p. 43). In the Cwmergyr or old Esgairlle mine there are several instances of the intersection of small lodes at various angles.

The Meeting of Two Lodes without Crossing.—The appearance of intersection may be produced by two lodes approaching so as to come into contact for a space and then diverging without actually crossing; unless the individual lodes are recognisably distinct it is not possible to distinguish this case in practice from the foregoing.

A more common occurrence is a variation of this latter case where the two components of a composite lode diverge and then meet again each forming a curve and enclosing between them a loop or "horse" of country-rock which may attain a width of several hundred yards. The best example is that of the Kingside and Comet lodes on the west side of Copper Hill, Cwmystwyth (see p. 31 and Pl. VII.). In this case the principal lodes are connected by several minor lodes or branches which traverse the wedge of country included between them. This type presents several features in common with that near Bwlchglas described above; on a smaller scale it is frequently met in underground workings.

The Displacement of Lodes by other Lodes and Faults.—A displacement or heave of one lode by another is comparatively rare so that it is not usually possible to decide if one of two intersecting lodes is later than the other, and, in general, it may be suspected that the lodes are of approximately the same age.

Two examples which are described in detail elsewhere may be referred to in this connection where there is definite proof of such displacement. One is at Cwmystwyth where Mitchell's lode intersects and displaces the Kingside and Comet lodes at two points. Mitchell's lode hades to the north or north-west and at one point behaves as a normal strike-fault throwing down northward both the Kingside and Comet lodes which hade to the south. At another point Mitchell's lode swings round into a south-westerly direction and crosses the same lodes almost at right angles, then behaving as a normal dip-fault with a westerly downthrow. It is noteworthy that Mitchell's lode is productive for a considerable distance away from the point

of intersection and it does not appear probable that it has derived its ore at second-hand from the lodes which it traverses. The other example is the cross-course at Glogfach and Glogfawr which behaves as a normal fault and throws the north-hading lodes in those mines several fathoms down west. The cross-course only carries ore at and near its intersection with the east-and-west lodes and may have derived it from them.

Two east-and-west faults merit special consideration in this connection, as there is no doubt that one, if not both, belongs to a period later than the formation of the lodes and their filling. The Llyfnant fault has been described in detail¹ and shown to be on the whole a downthrow to the north. Its most peculiar feature is the amount of horizontal movement which has taken place along it. Several anticlinal and synclinal axes and strike-faults were all displaced eastwards on the north side for distances varying from 570 to 1,070 yds., whereas the greatest vertical movement is only just over 200 yds. Its average course is a few degrees south of west and north of east, and is thus oblique to the majority of the lodes of the district. Although the Llyfnant fault does not intersect any lodes its direction and its influence upon the drainage-system in that neighbourhood suggest that it is, like the Ystwyth fault, more recent than those structures.

The Ystwyth fault is one of the largest faults in the country. It runs in a direction a few degrees east of north for a distance of 20 to 25 miles and at Pontrhydygroes can be proved to be a normal fault with a downthrow to the north of at least 1,050 yds.; at Cwmystwyth its throw is somewhat less, but even there is certainly more than 700 yds. It not only displaces the geological boundaries for several miles, but at Cwmystwyth it interrupts the lodes and "has left them without any apparent continuation on its south side" (Smyth, p. 664). Many trials have been made at various times to discover these lodes south of the Ystwyth valley at Cwmystwyth, but without success. There is little doubt, however, that the Comet lode of this district is represented on the other side of the Ystwyth fault by the Logaulas lode of the Pontrhydygroes district, which pursues a parallel course but at a distance of more than half a mile to the south (*see* p. 36). Unfortunately, near Cwmystwyth the fault, instead of maintaining its course in the direction of the valley, leaves it somewhat abruptly and crosses the hill into the upper part of the Elan valley: thus intersecting at a considerable angle the course of any lodes that may occur south of the Ystwyth. If it were not for this fact the downward continuation of the great ore-body worked for centuries at Cwmystwyth might be located south of the fault.

The Influence of the Country-Rocks upon the Contents of the Lodes.—It appears to be agreed that the nature of the country-

¹ O. T. Jones and W. J. Pugh, *Quart. Journ. Geol. Soc.*, Vol. lxxi, p. 373.

rocks exercises some influence upon the lodes which traverse them, but the effects are not the same under all circumstances.

Smyth (p. 667) states that the lead-veins of this part of Wales differ from those of Cornwall in that "when they pass from a harder to a softer rock, their mineral contents decrease," and he gives instances of this from Cwmsymlog or East Daren mine. On the other hand, we have from the same mine evidence that when the lode traversed the beds of "porphyry" (grit) in some of the lower levels the productivity of the lode was seriously affected (*see* p. 66).

Again in the Brynrafr mine the lode is several feet in width and productive in the Upper Van formation, but when it enters the hard grit-beds of the Lower Van formation it is represented merely by a few inches of spar. Conditions were apparently similar in the Plynlimon mine which is situated in the same formation. In the Van mine, however, enormous deposits of ore have been discovered in fissures, joints, and other lines of weakness traversing the grits of the Lower Van formation (*see* p. 159 and Pl. XXIII). These deposits lie to one side of the Van lode and form what are termed the "flats." The Van lode itself has not been proved at that point, and it is not known what influence, if any, the grit beds have upon it. At Cwmystwyth, too, the lodes become barren on passing from the grits into the underlying shales. The notions about the nature and behaviour of lodes which prevailed rather more than a century ago are well expressed in Meyricks' "History of Cardiganshire," (p. cciii) and as they have undergone little change to this day the account is worth reproducing.

"Innumerable cracks and fissures, by the miners called lodes, are found . . . ; but these differ so much, in size and shape, that it is impossible to form any inference from their size and shape in one place about that in another. In these lodes the metallic ore is met with. . . ."

The inner part of the fissure in which the ore lies, is all the way bounded by two incrustations, resembling walls of stone, which are generally parallel to one another, and include the breadth of the vein or lode. There are not however many of these fissures, which have regular walls, until they have been sunk down some fathoms. Whatever angle of inclination some fissures make in the solid strata at their beginning, they generally continue to do the same all along. Some are very uncertain in their breadth, as they may be small at their upper part and wide underneath. Their regular breadth, as well as their depth, is subject to great variation; for, though a fissure may be several fathoms wide in one particular place, yet a little farther east or west it may not perhaps be one inch wide. This excessive variation happens generally in very compact strata, when the vein or fissure is squeezed, as it were, through hard rock, which seem to compress and straighten it. A true vein, or fissure, however, is never entirely obliterated, but always

shows a string of metallic ore or of a veiny substance, which often serves as a leader for the miners to follow, until it sometimes leads them to a large and richly impregnated part. Their length is in great measure unlimited, though this cannot be said of the space best fitted for yielding metal. When two metallic veins in the neighbourhood of one another, run in an oblique direction, and consequently meet together, they commonly produce a body of ore at the place where they intersect; and, if both are rich, the quantity will be considerable; but if one be poor, then both are either enriched or impoverished by the meeting. After some time they separate again, and each will continue its former direction near to the other; but sometimes, though very seldom, they continue united. It is a sign of a poor vein when it separates or diverges into strings; but on the other hand, when several of them are found running into one, it is accounted a promising sign. Sometimes there are branches without the walls of the vein in the adjacent strata, which often come either obliquely or transversely into it. If these branches are impregnated with ore, or if they underlie faster than the true vein, this is, they dip deeper into the ground, then they are said to overtake or come into the lode, and to enrich it; or if they do not, then they are said to go off from it, and to impoverish it. But neither these nor any other marks either of the richness or poverty of a mine are to be entirely depended upon; for many mines, which have a very bad appearance at first, do nevertheless turn out extremely well afterwards; while others, which in the beginning seemed very rich, turn gradually worse and worse; but in general, where a vein has a bad appearance at first, it will be imprudent to be at much expence in working it."

Another idea which is commonly entertained by the miners of the district is that a lode which traverses country diversified by strike-ridges ("cripiau") and hollows, as most of them do, is barren where it crosses a ridge and productive, if anywhere, in the hollows. The ridges which frequently, though not always, consist of harder rocks, are said to compress the lode. This belief appears to be at variance with the experience that soft rocks in the walls of the lode produce a deterioration in its content, since in many cases the hollows mark the outcrop of the less resistant strata. Moreover, owing to the close folding which affects the rocks the average inclination of any given bed is low and a particular band of soft rocks which outcrops in a hollow usually passes under the adjoining ridge on one side or the other at no great depth below the surface, so that if productivity is related to that band of rocks, the lode under the ridge should also carry ore at some distance below the surface. Under the conditions which prevail in this district it is difficult to assign any sound reason for this belief.

CHAPTER II.

EAST-AND-WEST FAULTS AND LODES.

LODES OF CARDIGANSHIRE.

It will be convenient to discuss these structures in order from north to south, but as few, if any, lodes can be traced without a break from Cardiganshire into Montgomeryshire or *vice versâ* it will be an advantage to treat of the lodes of these two counties separately. This division separates the region into two fairly natural areas which lie east and west respectively of the Plynlimon range and the main watershed of the country. The district between Machynlleth and the Llyfnant valley falls, however, into Montgomeryshire, although it lies in the western division but none of the east-and-west faults in that area have been proved to be metalliferous.

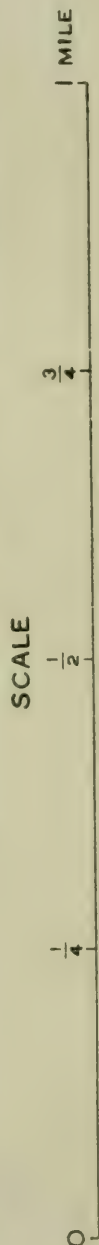
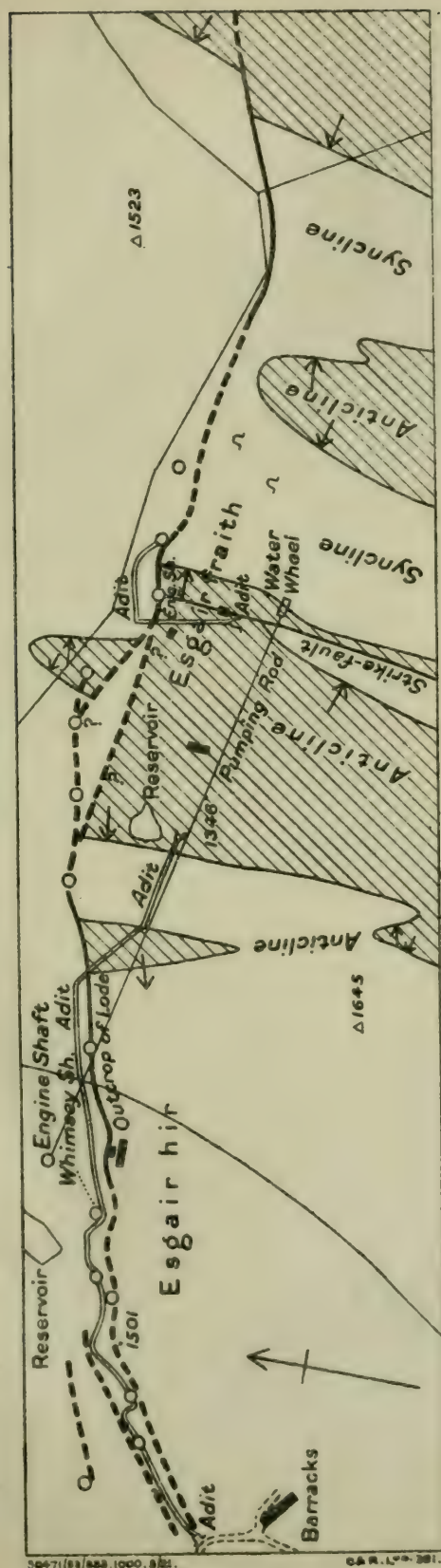
Some of the lodes can be traced for long distances and have been worked at several points, but others are, so far as is known, confined to the neighbourhood of one mine.

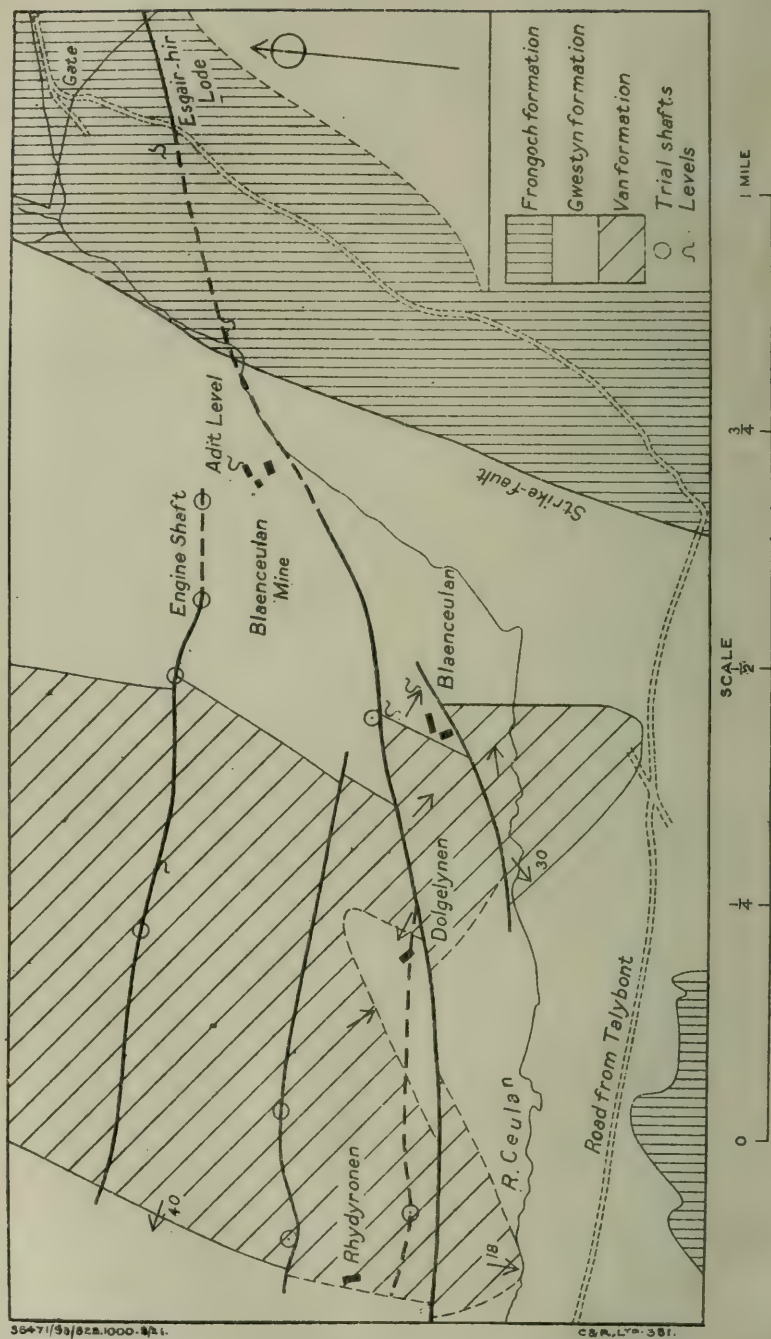
The Esgairhir Lode.—This lode has been known and worked for centuries and acquired great renown from the glowing reports made by Waller¹ in 1692 and 1698 on the riches contained in it and the profits that could be made by working its mineral deposits, but it had been exploited to some extent before his day. The lode is exposed at the surface and in opencasts for a considerable length near, and to the east of, the ruined mine-buildings. It underlies north at about 20° and is evidently several yards in width, though it is nowhere completely exposed. Francis² (p. 20) states that it varies from 20 to 60 ft. with solid ribs of galena from 1 to 6 ft. wide. It contains great masses of vein-quartz which, in one place, may be seen to form ribs near the footwall; where the lode crosses the road below the mine-buildings a width of 6 ft. of massive white quartz is visible. It is said that the lode was barren where its filling was largely of this nature. The material on the dumps consists of breccia of a pale-green slaty mudstone, traversed and cemented by veins of quartz with spots and strings of galena and blende, but in the more productive parts of the lode the ore seems to have been almost free from matrix. The mode of occurrence of the ore is discussed on p. 51.

The outcrop of the lode can be traced for over a mile eastward from the Esgairhir workings to Afon Llechwedd mawr (see Pl. IV); beyond this point there is no evidence of its existence. but some of the old miners believed that it was continued into the Dylife lode of Montgomeryshire. The rocks are everywhere thrown down to the north along its course; the displacement east of the mine must be at least 100 to 150 yds., but varies somewhat from point to point owing to the close

¹ W. Waller: "History of the Mines of Sir Carbery Price."

² History of Cardiganshire Mines.





GEOLOGICAL MAP OF DISTRICT NEAR BLAENAU CEULAN.

folding of the adjoining rocks. At Esgairhir it traverses the lower beds of the Frongoch formation, which on the whole dip westward. East of that mine an anticline brings the Gwestyn shales¹ to the surface; the outcrop of those rocks being narrower on the north than on the south side owing to the throw along the lode. Between this anticline and Afon Llechwedd mawr the Frongoch formation occurs on both sides though its base south of the lode is not far below the surface. In the Llechwedd mawr valley the Gwestyn formation reappears in another anticline.

About half a mile east of Esgairhir and probably on the same lode is a mine called Esgairfraith, where galena is replaced by copper-pyrite, associated with calcite and chalybite to the exclusion of other lode-filling. The copper-ore appears to be confined to the neighbourhood of the Gwestyn formation, and though it was believed to occur in a separate lode or branch lying slightly to the north of the galena lode, the evidence for this is not conclusive. About 80 yds. east of the Esgairfraith engine-shaft a vein of chalybite and calcite, about 3ft. wide, is visible and similar material associated with copper-pyrite has been dug 280 yds. north-west of that shaft. If the exposures are all on the same lode they indicate rapid, though not impossible, changes of strike in that locality.

West of Esgairhir the lode can be traced over the hill south of Bwlchygareg, its position being marked by a shallow depression, and across the Talybont road about 200 yds. south of the gate near the Bwlchygareg gap, where the rocks are shattered for a width of several yards. Beyond that point there is no evidence that it continues as a single lode, but there is little doubt that farther west it is represented by at least four small faults or lodes, each with a downthrow to the north, which cross the Van and Gwestyn formations north of Blaenceulan (*see* Pl. V). The northernmost of these was worked in the Blaenceulan mine; it passes to the north of the adit near the dressing-floor and is visible in the engine-shaft as a narrow lode dipping steeply northwards; about a third of a mile farther west it contains chalybite with copper-pyrite and galena. Where it crosses the base of the Gwestyn formation 500 yds. north of Blaenceulan farm, its downthrow may be estimated at 12 to 15 yds. About 100 yds. north of the house there is a shaft on another lode which is described on a small map of the Blaenceulan sett (preserved in the Home Office) as Walkers' or Esgairhir south lode; it causes a larger displacement of the base of the Gwestyn formation than any of the others, and near the shaft its downthrow is probably about 100 yds. to the north. It strikes towards the point where the Esgairhir lode was last seen on the Talybont road, and it may be regarded as the principal branch of that lode. Westward it can be traced beyond Dolgelynen farm and towards the middle of the Ceulan valley. Both these lodes according to A. Francis (p. 9) yielded copper-pyrite as well as galena.

¹ These shales are indicated on Pl. IV by shading.

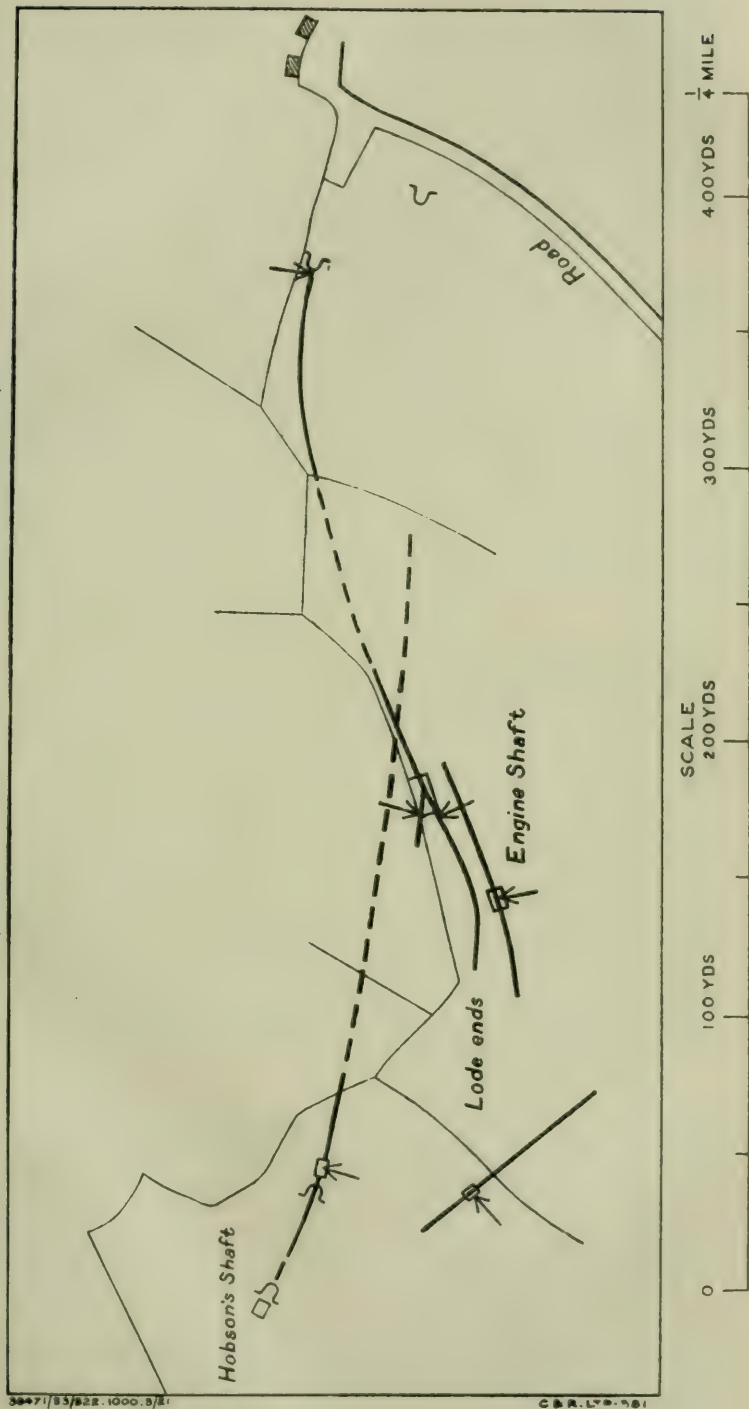
About 80 yds. to the north is another small fault with a northerly downthrow of about 10 to 15 yds. This is probably a branch from the last which diverges westward on a nearly east-and-west course. In a gully north-east of Rhydyronen farm it is seen to dip northward, and a little farther west calcite and chalybite occur in the dump of an old shaft sunk on it. South of Blaenceulan farm another northerly downthrow of about 40 yds. can be traced south-westward towards the Ceulan valley south of Dolgelynen; in the other direction it probably joins Walkers' lode near the Blaenceulan dressing-floor. From the manner in which all these faults converge eastward in the direction of Esgairhir there is little doubt that they represent the lode of that mine which has split up in the upper part of the Ceulan valley. It is significant too that the downthrow of each is northward, *i.e.*, in the same direction as that of the Esgairhir lode, and that the sum of their displacement (162-172 yds.) is comparable with the throw of that lode farther east (100-150 yds.). The presence at several points of copper-pyrite associated with chalybite and calcite as at Esgairfraith, is further evidence in support of this conclusion.

These lodes cannot be traced with certainty beyond this neighbourhood, but there is evidence in the Ceulan valley about a mile farther west of one or more displacements in the base of the Gwestyn formation, though the exposures are too limited to allow their effect to be determined. It is not improbable, however, that the fractures continue along that valley, and there may be some justification for the view expressed by A. Francis (p. 5) that the lode at Penpontbren, north of Talybont, is the Esgairhir lode, but it can only represent a part of that lode.

As the mines around Talybont lie in the continuation of these fractures, it is an advantage to consider them at this point.

Erglodd Lodes.—This is a group of three small lodes which have been worked in the Erglodd (Eurglawdd) mine two-thirds of a mile north of Talybont, and are known only in that locality. The middle lode which was worked in the shafts on the summit of the hill ranges nearly east-north-east, but east of the engine-shaft it is joined by a small branch dipping south at about 75° . About 100-150 yds. west of the engine-shaft some opencast workings appear to represent a third small lode lying somewhat to the south of the latter.

Penpontbren Lodes.—These form another network of small fissures intersecting one another on the ridge about half a mile north of Talybont; the majority of them underlie north, but the most northerly one, which is seen at the mouth of an adit (about 380 O.D.) west of the road 300 yds. north of Penpontbren, dips south at 75° to 80° (Pl. VI.). A short distance west of the adit-mouth it has been worked in a wide opencast and appears to have been from 2 to 8 yds. wide. At the summit of the hill what is probably the same lode and its branches are visible



NETWORK OF LODES AT PENPONTPREN.

with a similar dip in the old shafts, but immediately to the south a narrow joint-love dips north into it. A few yards west of the shaft the love first becomes barren, and then disappears. Between the shafts and the adit-mouth it is intersected by a joint-love which is visible again farther west in excavations on the wooded slope overlooking the main road from Talybont to Glandovey, where it dips north at about 60° . At the lower edge of the wood an adit has been driven east on it; and a shaft (Hobson's shaft) sunk to about 20 fms. below. Another narrow joint-love, dipping north-east, is visible in the wood about equidistant from the shafts and the western adit. It was probably at the intersections of these various fissures that the bunches of ore which were worked there were obtained. A. Francis (p. 5) states that good courses of lead- and copper-ores were found at these junctions. A few yards south of the eastern adit is a heap of blende-bearing rock which appears to have been derived from an adit on the north-dipping love. About 200 yds. south of the Penpontbren shafts a small love ranging west-north-west across the ridge has been tried.

A love with a southerly dip has been worked for galena in the Tanyrallt mine about 150 yds. west of the farm; its direction and inclination suggest that it may be the continuation of the north love at Penpontbren.

Alltycrib, Talybont.—The ridge overlooking Talybont is traversed by several loves and branches, all of which hade to the north. Two narrow loves are exposed in opencast workings and adits on the eastern slope of the hill; one of these can be traced due west to an old shaft called Child's shaft, near the edge of the wood on top of the hill. About 100 yds. to the south another love bearing almost exactly east and west has been worked in Alltycrib Wood and on the common to the west; old workings and trials extend nearly as far as Capel Bethania, south of Staylitttle, and throughout this distance there is evidence at intervals of a narrow love parallel to the last, at 10–30 yds. north of it. The filling of all these consists of a breccia of rather soft dark slaty mudstone with quartz. The galena formed narrow ribs or was thinly scattered through a considerable body of rock.

South of the last group a love has been tried on the common west of Alltycrib and another in the wood still farther south. In a shaft near the wood this love, sometimes known as the Cwm Leri love, exhibits an acute knee-shaped bend. It crosses the River Leri about a quarter of a mile below Talybont. According to A. Francis (p. 8) some lead-ore was obtained in the river-bed.

The numerous fissures which traverse the Penpontbren ridge and Alltycrib are not improbably the westerly continuation of the fractures which have been traced in the Ceulan valley. Reasons have already been given for the conclusion that

these are the split-up portions of the great Esgairhir lode, and it seems likely that the fissures in the Talybont district represent a further stage of the same process, though the continuity of any lode in that district with those farther east is not capable of proof.

It is a feature of the Talybont district that, although the rocks are much fractured and strongly mineralised, none of the lodes appear to persist far. Their mode of occurrence is similar to that of the "stockworks" found in many mining regions. Moreover, in Alltycrib mine the walls of some of the lodes were indefinite, and the ore was scattered through the adjoining country-rock in a way suggestive of impregnation. Mining operations in this district have, therefore, been somewhat hazardous.

The Hafan Lode is named after Cerig yr Hafan at the head of the Cyneiniog valley, 4 miles east of Talybont, where its effect is best displayed. It was known to Waller in 1698 as the Bwlch Kaniniog lode and he was then engaged in driving a level to prove it. It is sometimes known, farther west (Bwlchglas), as the District lode.

The ridge of Cerig yr Hafan is formed by an anticline in the massive grits of the Van formation which outcrop in a long narrow oval, the result of a northerly pitch of the fold at the north end and a southerly pitch at the south end. These grits are surrounded by a narrow band of Van mudstones, and these again by the Gwestyn formation. The centre of the ridge, where the change of pitch occurs is crossed in an east-north-easterly direction by a wide groove, along which ran the old tramway from the Hafan quarries. The depression is caused by the two faults both downthrows to the south, which make up the Hafan lode at this locality; their combined throw is 65-85 yds., the northern fault having about twice the displacement of the other. At the surface they are about 30 yds. apart, but are said to approach one another underground. Smyth (p. 663) records that the lode in the workings contained large ribs of calcite enclosing angular lumps of galena, copper-pyrite and blende. East of the old Hafan shaft the lode turns east-south-east across a narrow syncline in the basal beds of the Frongoch formation, and ranges thence for Brynyrafr mine. Its downthrow in crossing the syncline is not more than 20 to 40 yds., and appears to decrease eastward. Near the Camdwr valley it is exposed in a new adit (Newmarsh adit, O.D. 1147) driven westward in the Gwestyn shales, and carries blende. At Brynyrafr it traverses the Van formation and its displacement is probably only a few yards; at the same time its dip increases almost to verticality. It carries galena and blende, associated in some parts with a considerable amount of marcasite and quartz. East of the mine no displacement can be traced in the base of the Gwestyn formation and the lode apparently dies away in that direction. There is no evidence that the lode divides

east of the Hafan shaft but a considerable change in its character and displacement sets in about that point.

West of the Hafan anticline the lode can be traced along the foot of the southern slope of the Cyneiniog valley towards Bwlchglas mine, and half a mile east of that mine its displacement is comparable with that at Hafan. At Bwlchglas the lode was intersected in both the shallow and the deep adit cross-cuts, and in each there are two fractures 10 to 15 yds. apart, dipping to the south at 70° to 75° , and ranging almost east-and-west; one of these is filled with coarsely crystallized vein-quartz.

The western end of the shallow adit encountered a strong lode ranging west-south-west and consisting of quartz-breccia full of cavities; in the deep adit nearly underneath this point an open water-bearing fissure having the same direction was intersected and a cross-cut to the north from the 35 fm. level was driven through a considerable width of coarse lode-matter. From the position of these various fractures underground it may be inferred that they pertain to the Hafan or District lode which has been mapped on the surface. No ore has hitherto been proved to occur in that lode, but in driving the deep adit west of the open fissure mentioned above, a great mass of blende has been encountered recently, which appears, so far as it has been exposed, to be associated with the Hafan lode.

At the surface opposite the western end of the mine there is evidence of two distinct branches; the southern may be regarded as the main part of the Hafan lode which takes a markedly curved course; the northern branch forms a chord to the curve. The two branches unite at the point where the lode crosses the base of the Frongoch formation.

Near the stream south-west of Bwlchglas farm a wall-like mass of crushed Gwestyn shales and vein-quartz about 30 yds. wide marks the position of the outcrop, and near it occurs one of the rapid changes of strike or swerves which are a feature of this lode. Between this locality and the Cefngwyn mine there is some difficulty in tracing the outcrop. At Tynewydd and Moelglomen trials have been made on small branches, which are possibly off-shoots from it and a great mass of vein-quartz ranging a few degrees north of west, which is exposed by the roadside half a mile west of the ford near Tynewydd, may represent another branch.

Near Cefngwyn, in the Leri Valley north-west of Elerch, the lode is exposed with its usual characteristics of a wide mass of coarsely crystallized vein-quartz with some calcite, lumps of galena, blende and copper-pyrite, but workings on it have not yielded much ore. A few yards to the north a narrow joint-lode with steep northerly dip has apparently proved more productive; it is not improbable that, as at Bwlchglas, this is another branch off the main lode near one of its sudden swerves. Some pieces of quartz from the workings at Cefngwyn contain

large cavities indicating that scalenohedra of calcite have been dissolved out.

From Cefngwyn the outcrop of a lode has been exposed at intervals ranging southwestward towards Mynyddgorddu mine where a lode believed to be the Hafan lode was proved to be about 18 ft. wide. When it was exposed at the surface 40 to 50 years ago it contained large blocks of solid galena several hundred pounds in weight; the other components of the lode are crystallized calcite, quartz and blende. The various levels indicate an average course a few degrees north of west, and, if the lode is the same as that traced from Cefngwyn, a change of strike of 30° to 40° takes place at the east end of the mine. It is not improbable that this sharp deflection has favoured the deposition of the ore.

One-third of a mile to the west the same lode was worked in the small Elgar mine where it is said to have a similar width. A. Francis (p. 16) states that, at about 20 fms. east of the adit, the main lode was joined from the south by a silver-lead lode, supposed to be that called the Penycefn north lode, which was discovered about 1850 in cutting the foundation for the 40-ft. wheel in that mine. Nothing is known of the Hafan lode west of this point.

It is a remarkable fact that in a lode of such persistence and width little ore has been found and that restricted to narrow channels of ground. The chief ore-bodies appear to have been found in branches given off from the main lode, usually at points where rapid changes of strike occur.

The Camdwr Lode is one of the largest and most persistent in the district; it can be traced in an east-north-east direction for a distance of over 7 miles in Cardiganshire and is probably continued in Montgomeryshire as the Dylife-Dyfngwm lode belt (p. 41).

Yet it is singularly barren of ore, except at its two extremities, where the Dylife and Bronfloyd mines are situated on it and its ramifications. In the intervening ground several ore-bodies have been tried, but all have proved to be of limited extent.

Camdwr mawr from which the lode is named is situated on the Camdwr stream, a tributary which enters the Rheidol about 4 miles north of Ponterwyd. The lode traverses, on Drosgol hill, the Van mudstones and grits, against which a narrow syncline of Gwestyn shades is thrown on the north. Its vertical displacement at this point can hardly be less than 200 yards; there is also some horizontal movement, for the axes of the folds which it intersects have been moved eastward on the north or downthrow side.

The adit of the Camdwr mine is driven eastward from the base of the Gwestyn formation into the underlying beds; on the east side of Drosgol some low-grade manganese-ore (psilomelane) has been obtained in one or two adits but not in paying quantity..

West of Camdwr the lode crosses several anticlines and synclines in the Van and Gwestyn formations. It was rather extensively tried at Bwlchystyllen about a mile and a quarter south-west of Camdwr, but the venture proved unprofitable.

It is visible as a wide belt of shattered rocks in the precipice and cascade called Craigypistyll, and in the Leri valley below these rocks it has been worked in the Llawrcwmbach mine, where it is said to have a width of not less than 60 ft.

At Craigypistyll the mudstones and grits of the Van formation are folded into an anticline south of the lode and the Gwestyn formation bounds it on the north; here, again, the northerly downthrow must be 200 to 300 yds.

About a mile west-south-west of Llawrcwmbach a rich bunch of lead-ore was found near the surface in the Lletty Evanhen or Llettyhen mine (later called the Vaughan mine), and subsequently a long adit was driven under it from the valley south of Lletty Evanhen. At several points between Llawrcwmbach and the mouth of the adit manganese-ore has been obtained in association with pinkish and red-stained shales such as are frequently found accompanying that ore. Some of it was obtained in a short adit cross-cut south of the Leri valley, near Llawrcwmbach, and a pocket over 2 ft. wide was worked near the track 600 yds. east of the Llettyhen engine-shaft. A cross-cut south from the deep adit or 55-fm. level, about 100 yds. east of that shaft, also entered a deposit of manganese-ore, and several tons were raised from an old shaft near the mouth of the deep adit, and in that adit itself. All these occurrences lie near the footwall of the lode, and in some cases they appear to form pockets in the country-rock below the footwall, but it has not been possible to examine any of them underground. Throughout this tract the lode has a width of 60 to 100 ft., the galena being found usually near the hanging wall.

Galena and some copper-pyrite were found in shafts and surface-excavations on the south side of the valley west of the Llettyhen deep adit, where the old Llechweddhelyg or Willow Bank mine is situated.

From this locality the outcrop of the lode can be traced by surface-excavations towards the road from Penrhyncoch to Cwmsynlog, which it crosses east of a group of cottages, passing thence into the valley of Nant Silo, and Bronfloyd. At the latter place, and for a mile to the east the strike of the lode is nearly N.E.-S.W. At Bronfloyd two lodes which are known as the "north lode" and the "middle lode" have been worked extensively; a "south lode" has also been tried in a short adit.

The two principal lodes have an average dip to the north-west of 68° , and in the workings are almost parallel, though they are said to converge eastward. Their outcrops are visible at the surface at a distance apart of about 100 ft. The south lode

appears to be only a few feet south of the middle lode. In view of the great width of the Camdwr lode along its whole extent it may be suggested that the ore at Bronfloyd is found principally in two positions within it, the middle and south lodes being near the footwall, and the north lode near or at the hanging wall.

The rocks at the surface are soft shales, which are at a vertical distance of about 3,000 ft. above the base of the Frongoch formation and have a general westerly dip. The upper levels lie in these strata and are barren; below them lie the chief ore-bearing rocks of the district and it was in those that ore was found. If this mine is reopened the deeper levels offer the best prospect. This is a consideration which affects equally other mines lying near the western limit of the productive area.

Castell Lode.—This lode takes its name from the Dyffryn Castell mine (New Castell or Cripiau bach), on the south side of the Castell valley 2 miles east of Ponterwyd. It is visible in a considerable length of open-cast workings and has the effect of a downthrow to the south of 100–120 yds.; it is bounded on the north by the Gwestyn shales, and on the south by the basal beds of the Frongoch formation, which are sharply folded. A narrow outcrop of the highest rocks of the Gwestyn formation appears also south of the lode in the ravine (Nant Meirch) east of the mine, and a larger area in the valley a quarter of a mile south-west of the mine; these rocks must underlie at no great depth the Frongoch rocks of the syncline, in which the main ore body is situated.

In the opencast west of the engine-shaft, a vein several feet in width, of calcite and chalybite with spots of blende and copper-pyrite, is exposed near the footwall of the lode, and the same minerals occur in a similar situation in the levels at the east end of the mine.

The great opencast east of the engine-shaft contained a large mass of blende which has now been removed. The lode is, in places, over 60 ft. wide, and for over 100 yds. ranges N.E.–S.W., from here the main part of it swings round into an east-and-west direction as far as Nant Meirch, where it again takes up its former course. About 600 yds. N.E. of the mine, a trial-shaft and adit yielded calcite, quartz, galena and copper-pyrite. The lode is exposed again in the dingle near Fagwrfawr farm, where it consists mainly of soft clay and shattered rock. Thence it can be traced, always as a downthrow to the south, along the slope to the east of an old quarry north-east of Fagwrfawr, and is located again by a wide belt of shattered rock exposed in the stream near Cwmergyr farm. Beyond this point it probably continues on the same bearing along a depression in the hill above Cwmergyr, to appear in the Tarenig valley where a fault of the same effect can be traced.

North of Cwmergyr a system of small lodes ranging approximately east and west, which were worked in two mines, must

join the Castell lode at some distance within the hill; these lodes will be discussed on p. 93.

From Dyffryn Castell the lode can be traced in a south-westerly direction to the Rheidol about a mile below Ponterwyd, where the river follows the fracture-line for over a third of a mile before turning south near the Temple mine. That mine worked ore in a small lode which lies to the south of the main lode and is probably a branch from it. Lewis Morris, writing in 1751, records that a rib of galena 4 in. wide was visible in the bed of the river some distance east of the mine. From the river the lode follows a gully and a wide deep depression through the Llwynteify and Bwlchgwyn mines (both situated on this lode or its branches) to Penrhiw and thence north of the village of Ystumtuen to the Rheidol valley near Tynyfron. The Ystumtuen or Cwmrheidol mine works the lode under the ground west of Ystumtuen by means of long adit crosscuts; while the western portion of the ground is worked from the Tynyfron adits. Near Penrhiw mine the lode exhibits two sudden deflections or swerves within less than a quarter of a mile; one near Bwlchgwyn mine from about N.E.-S.W. to E.-W., and the other west of Penrhiw, where it resumes its former direction; at each deflection a branch is given off. The effect of these two swerves is to throw the lode nearly a quarter of a mile out of its course as if it had been heaved by a cross-fault. It has throughout a general south-easterly dip of 60° - 75° , and behaves as a normal fault with a downthrow of not less than 100 yds. The Tynyfron adit appears to be the most westerly point, where it has been identified with certainty.

On the line of the lode and about 400 yds. west of Tynyfron, the Caegynon mine worked a lead-lode on the north and a blende-lode about 10 fms. to the south. In an opencast a few yards east of the engine-shaft a wide belt of shattered rock with several well-marked walls carrying blende and gossan, is exposed, and, so far as can be judged from the limited exposure, this belt ranges in the direction of Tynyfron. Its appearance suggests that the footwall is farther north, and may coincide with the outcrop-position of the north lode of Caegynon. The lode-stuff in the dump consists of brecciated mudstones of the Frongoch formation, associated with blende, galena and marcasite.

South of the Rheidol several lodes have been worked from shafts and adit cross-cuts, but all appear to dip north and have not been recognised on the opposite side of the valley. None can be identified with the Castell lode, but the occurrence of so many north-dipping lodes suggests the possibility that the continuation of that lode is to be sought to the north of all of them. That great fracture, which can be traced for many miles across country and maintains its size and displacement throughout, is not likely to die away in the distance of less than half a mile which separates the north from the south slope of the Rheidol valley.

The Lodes of the Cwmystwyth District.—Cwmystwyth offers a remarkable association of lodes and structures, and there has always been some confusion as to the number of lodes and their relation to one another. On the plans of the Cwmystwyth mine about 30 lodes and their branches are represented. Some are comparatively unimportant and of restricted extent, but in different parts of the mine six or eight important lodes are distinguished. The examination of the plans and of the lodes on the surface has, however, shown that most of them are different portions and branches of three main lodes. It is not unlikely also that the two principal lodes, viz., the Comet and the Kingside, are really subsidiary fissures in one great fracture-belt; both dip to the south at from 50° – 65° but their characters are distinct. The Kingside lode usually lies a few fathoms south of the Comet and keeps separate from it, but in Graigfawr (or the Great Rock) overlooking the mine they run together; east of this point the Kingside crosses the Comet, and a little farther, near Copper Hill, pursues a widely different course. The third lode dips to the north at 45° to 60° , and in the part of the mine where it has been most extensively worked, is known as Mitchell's lode. In the central parts of the workings, opposite the mill, it pursues a course parallel to the other two, but intersects them in various levels, and throws them down north through several fathoms; although mineralized and in places a highly productive lode, it is, thus, clearly of later date than the Comet and Kingside. In the western workings around Pugh's shaft, Mitchell's lode swings round southward and intersects the principal lodes nearly at right angles, heaving them many fathoms to the north on the west side, thus acting again as a normal fault with a downthrow on the hanging side. The evidence for these conclusions is given under the description of Cwmystwyth mine.

The Comet lode in the main workings is from 12 to 40 ft. wide and usually has a clearly-marked footwall; the lode-filling consists of fragments of country-rock with crystallized quartz and occasionally calcite; it carries a mixture of galena and blende, usually in large continuous bodies, and in the western end of the mine these are associated with a considerable amount of iron-pyrite; the small branches which spring out from the main lode are generally filled with galena. The waste-heaps from the workings have a rusty appearance, and fragments of the lode near its outcrop may be readily recognised by this character. On Copper Hill, east of Cwmystwyth, the Comet consists of a mixture of blende, galena and a considerable proportion of copper-pyrite in a matrix of calcite, dolomite and quartz, together with angular fragments of country-rock. Here, also, it is an open lode several fathoms in width.

The Kingside lode, which attains its chief importance in the central and eastern workings, is represented at the west end of the mine by the so-called "main lode." It has an average

width of about 3 ft. and is more compact than the Comet; it is filled principally with massive quartz and galena, carries no pyrite and but little blende. In one part of these workings this lode between the 15- and the 30-fm. levels became a "flat" ("the Great Flat"), where for an area of at least 150 sq. yds. a mass of galena, lying almost horizontally with a constant thickness of 6 ft. 2 in. between its roof and its floor, was worked. No trace of this "flat" was met in the 30-fm. and deeper levels, and its southern limit was formed by the so-called "soft ground" or Ystwyth fault.

Mitchell's lode is somewhat variable; above Mitchell's level it contained open cavities or "vughs," and in these large masses of galena were found. Between Mitchell's level and Gill's Higher level the galena occurred in solid ribs; below the latter, down to the 15-fm. level, blende was the main filling, and even in the 30-fm. level that ore predominates over galena. The lode is comparatively narrow, with a little quartz, most of the filling being ore, which in places consisted of over 3 ft. 6 in. of blende.

In the ravine east of the dressing-floors, the Comet outcrops near the path to Graigfawr; 30 or 40 yds. to the south is the outcrop of the Kingside which, in the stream, comes into contact with Mitchell's lode dipping north at about 45° . The other lodes dip south at about 60° (see Pl. XVII).

Immediately south of Mitchell's lode a part of the Comet outcrops again, and about 30 yds. down the ravine is a second outcrop of the Kingside. Both lodes are, therefore, thrown down to the north on meeting Mitchell's lode, and their outcrops are repeated.

In and under Graigfawr, east of the ravine, the Kingside crosses the Comet, and about 300 yds. farther east goes off in a north-north-easterly direction along the slope west of Nant yr Onen, the stream that divides Copper Hill from the main workings of Cwmystwyth; it contains here a large amount of blende with galena and coarsely crystallized clear quartz. Near a large opencast-working it turns across the stream and ranges east-north-east across the north end of Copper Hill. On the other hand the Comet, where it parts from the Kingside, turns almost due east towards Copper Hill, where its outcrop is indicated by several adits and surface-workings. It has not been found on the summit of that hill, though rock is exposed almost everywhere, and presumably it turns northwards along a marked depression west of the summit to form another junction with the Kingside. This junction is probably about 300 yds. north of the trigonometrical station (B.M. 1676.7) on Copper Hill (Copa Hill on the Ordnance map).

The ground between the two lodes on the west flank of the hill forms a large "horse" of lenticular shape, three-quarters of a mile long from north-east to south-west and nearly a quarter of a mile wide; it is traversed by six or more strings

which cross from one lode to the other, thereby suggesting an intimate connection between the two (Pl. VII).

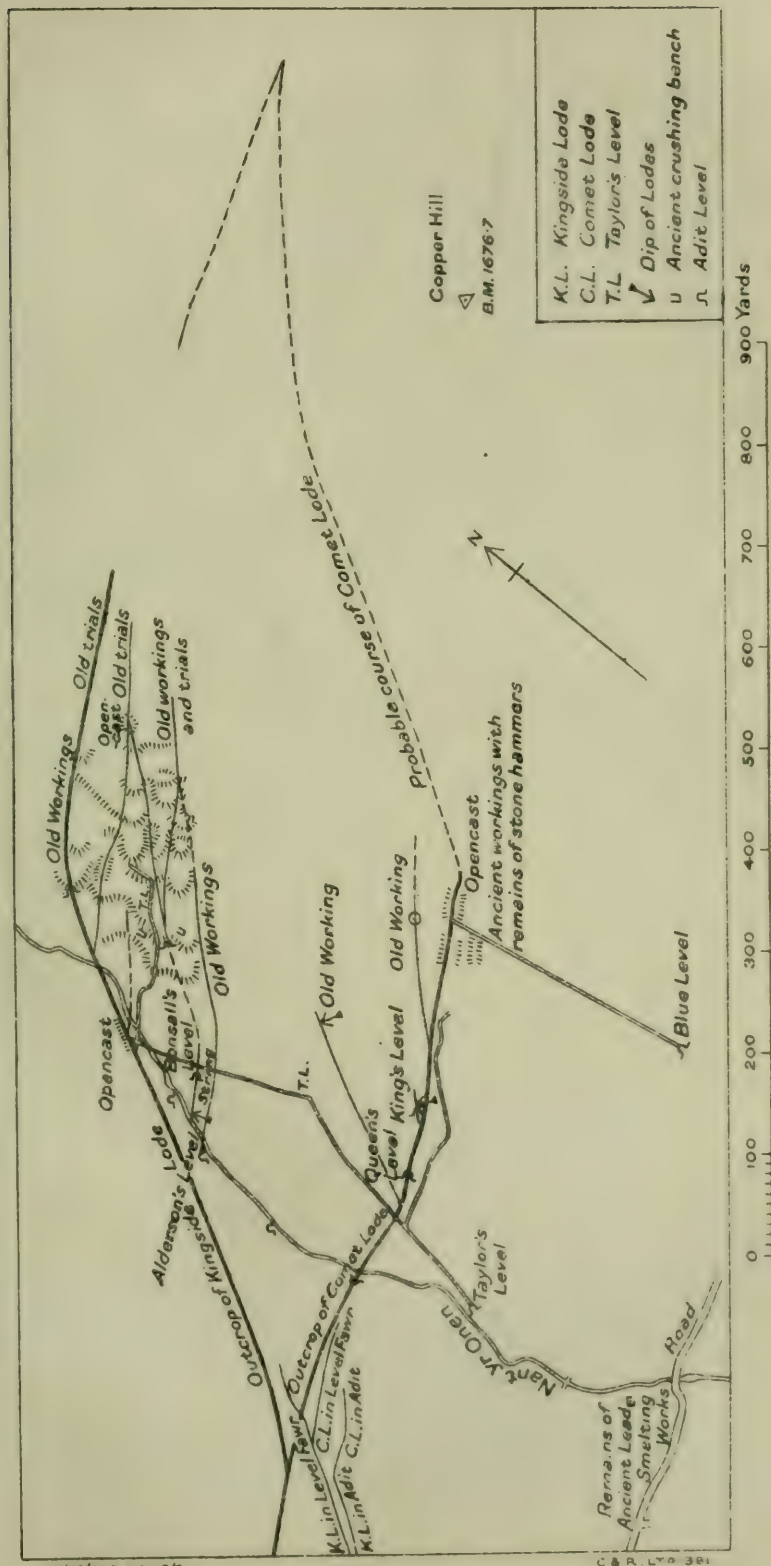
Judged by the enormous waste-heaps on Copper Hill, these strings as well as the main lodes proved highly productive in past times. Some of the adits must have been driven a long distance eastward, but it is doubtful if any of them reached the point which has been suggested above as the junction of the two lodes. Some of the workings on Copper Hill are probably of high antiquity; primitive stone implements are strewn about in places, and there are evidences of the crude methods adopted in dressing the ore.¹

From Copper Hill the course of the lode-belt can be traced by surface-features to a ravine called Ffrwd yr Ydfran, about two-thirds of a mile north of Blaencwm. In the walls of the ravine are two powerful fractures about 30 yds. apart, with well-marked walls dipping to the south at 60° to 70°, separated by greatly shattered rock. There is little doubt that they represent the Cwmystwyth lodes, and it is interesting to note the presence of two walls at about the same distance apart as the Kingside and Comet in the main part of the mine.

Evidence of the same fracture-belt is obtained nearly 3 miles to the east, near the source of the River Ystwyth. The highest grits of the Cwmystwyth formation are there succeeded by green mudstones which are folded into a narrow syncline. On the north side of the belt the boundary between these mudstones and the grits is displaced over 300 yds. to the west, but the movement has been mainly in a horizontal direction with little vertical displacement. From this point the fault follows the valley of Nant Troedyresgair into the neighbourhood of Llangurig.

About a mile west of Cwmystwyth mine a lode dipping south at about 60° has been tried in shafts and adits (Cwmystwyth W.), near the stream north of Pentre Briwnant. A few yards south of the footwall there is another fracture dipping in the same direction. This lode is on the strike of the Comet and, doubtless, represents it, but is unproductive. The base of the Cwmystwyth formation is shifted about 700 yds. by it, corresponding to a downthrow to the south of 200 to 250 yds. From this point its course can be traced for more than half a mile westwards; it ranges for a deep gap in the ridge in which Eglwysnewydd Church stands, thus pursuing a course parallel with the floor of the Ystwyth valley, but 300 to 400 yds. to the north. The Comet lode was highly productive in the massive grit-beds of Cwmystwyth, but became barren westwards as it approached the soft shales which lie at the top of the underlying Frongoch formation. Apparently a similar change took place near the base of the grits in the deep workings at the west end of the mine. Although no ore has been found in it west of Cwmystwyth, the course of the lode is of some interest

¹ See also Smyth, *Mem. Geol. Surv.*, Vol. ii., pt. 2, 1848, pp. 664, 667.



MAP OF LODS ON COPPER HILL. CWMYSTWYTH.

because of its relation to the Ystwyth fault which passes along the valley to the south.

The Logaulas Lode, which has been known and worked for a long period at Logaulas, about half a mile east of Ysbytty Ystwyth, is marked at the surface by a wide depression and by excavations. The lode-matter consists of breccia of pale Frongoch mudstones with quartz, calcite and some gossan, carrying cerussite fairly plentifully. The ore was found mainly in two strings, 90 to 100 ft. apart, but the whole width of the lode was somewhat mineralized. Throughout most of the mine galena was dominant, but small amounts of blende and copperpyrite occurred in association with it; towards the western end of the workings the lode was poor in galena, its place being to some extent taken by blende. The productive length of the lode at and near the surface was about half a mile, its course in this distance being about N. 40° E. with a dip to the south-east at about 60° . Near Worsley's shaft the strike becomes about E. 15° N., and east of that point the lode has proved to be all but barren, though its course, as indicated by a depression and other evidence, can be traced for a long distance. It ranges past Bwlch Gwalter farm south of Hafod, towards a point in the ravine a quarter of a mile south-east of Pont Dologau, where several feet of greatly shattered rocks, suggestive of a powerful fault, are visible in the bank. Various trials have been made on the higher slope south of the outcrop, but there is no evidence of any having been made on the course of the lode itself. East of the ravine a marked depression, extending towards the river south of Pentre Briwnant, clearly indicates its position. In this locality its outcrop is parallel to that of the Comet lode, but about half a mile to the south of it, and is also nearly parallel to the Ystwyth fault, which lies almost midway between them.

West of Logaulas the lode is said to have been found in the Pendre trial-shaft near the road, $\frac{1}{4}$ mile south of Ysbytty Ystwyth Church; it then passes under peat and boulder-clay across a tract which is occupied largely by the Gwestyn formation. These rocks are folded into a broad anticline, on the western flank of which the lode produces a shift of about 400 yds. in the base of the Frongoch formation, north of Hendrefelen; this corresponds to a downthrow to the south of about half that amount. Beyond this point the lode has not been identified with certainty, though adits driven eastward below Bron Caradoc, and approximately on its course, cut, according to Absalom Francis (p. 116), two lodes. One of these he supposed to be the Glogfach lode (which is extremely unlikely) and the other was about 3 ft. wide. He states that copper- and lead-ores occurred at the junction, and elsewhere in the adits driven on the two lodes.

The Ystwyth Fault.—Although not a lode, it is necessary to refer to this fault in some detail and to discuss its influence upon

the lodes of the Pontrhydygroes and Cwmystwyth districts. West of Cwmystwyth there are various trials along its course, which suggest that at one time it was believed to be productive, probably from the fact that the old miners in working the "Great Flat" against the fault in the western end of Cwmystwyth, found large masses of lead-ore in its soft clayey matrix, and made considerable burrows in searching for lumps elsewhere along its course. These masses, according to Mr. J. H. Evans of Cwmystwyth, were pieces torn from the flat during the movement and incorporated with other fragments of the adjoining walls in the fault-matrix. This interpretation, which seems reasonable, implies that the Ystwyth fault is not only of later date than the lode-fissures, but later even than the deposition of the ores within them.

The existence of a band of "soft ground" in the western workings of Cwmystwyth has been known for a long period; it is described by Smyth,¹ and indicated on the map, Pl. II. The true nature of this band has only been proved within the last few years by the detailed mapping of the lodes and of the boundaries of the formations.² It was crossed in Lower Gill's and in all the levels driven from Pugh's shaft (*see* Fig. 3). From its position at various depths the course and inclination of its upper and lower surfaces can be determined. It dips at about 65° to the north and the width of fault-rock varies from 90 to 110 ft. In Lower Gill's the fault-fissure is filled with gravel of glacial origin which rests on a striated rock-surface; similar gravel was met in the 15-fm. level about 40 yds. south of the Kingside shaft.³ The deposit is, however, confined to this locality; elsewhere the band consists of a great width of blue clay with small angular fragments of country-rock and an occasional lump of ore.

In the stream west of Pentre Briwnant, grit-beds occupying a horizon near the base of the Cwmystwyth formation are exposed north of the fault. To the south of it, the lowest grits, exposed near the top of the slope known as Graiggoch south of the mine, descend eastward with many undulations to the level of the alluvium near Doltwlc, half a mile east of the Cwmystwyth dressing-floors. The displacement thus amounts to a mile and a half. If the average easterly inclination of the rocks be assumed to be about 20°, the throw of the fault is about 900 yds., or just over half a mile, but this figure may be somewhat too large. The appearance and trend of the Ystwyth valley above Cwmystwyth naturally suggest that it has been influenced by the fault. Detailed mapping belied this anticipation; about 3 miles east of Cwmystwyth, the fault is a mile south of the valley, and the tradition among the old miners, that the "soft ground" passes under Doltwlc and then out of the line of the valley, appears to be

¹ Mem. Geol. Surv., Vol. ii., pt. 2, p. 664.

² O. T. Jones, *Quart. Journ. Geol. Soc.*, Vol. lxxviii., 1912, p. 343.

³ Smyth, *op. cit.*, p. 664.

correct. There is some evidence of a downthrow to the north in the upper beds of the Cwmystwyth grits at Craig y Lluest, near the head of the valley, which ranges through the hill called Yr Allt for the Ystwyth valley near Blaencwm. The displacement is, however, insignificant in comparison with that of the main fault, though it may be sufficient to account for the trend of the valley between that place and Cwmystwyth.

West of Cwmystwyth the "soft ground" was intersected in a long cross-cut driven in from the main road between Pentre Briwnant and Bwlchgwynt, where, according to a plan preserved in the Home Office, it is nearly 180 ft. wide. At various points in the Ystwyth valley between Pentre Briwnant and Pontrhydygroes its course is indicated by features or by disturbed rocks. At the latter place a band of clay, associated with a vein of calcite, about 6 ft. wide, is exposed in the river-bank. The vein is referred to by Smyth as a lode, but it would appear from its position and direction to be a part of the Ystwyth fault. At this point the fault leaves the valley but, after crossing Maenarthur Wood, enters it nearly a mile farther west, where its position is indicated by shattered rock exposed in the Pengrogywnion brook about 600 yds. north of the river. The effect of the fault at Pontrhydygroes is to bring up to the surface on its south or upthrow side the Gwestyn formation which is exposed over a considerable area. The nearest exposure of these rocks is about 4 miles to the north where over a wide extent a southerly pitch of about 10° prevails. With such a pitch the Gwestyn formation north of the fault at Pontrhydygroes would be about 3,500 ft. below the surface, whereas the rocks which are exposed to the south of it are 200 to 300 ft. below the top of that formation. The survey of the district around Pontrhydygroes has shown, however, that the southerly pitch is less than in districts farther north, but there is no evidence in this or the intervening area that it is anywhere reversed in direction. Taking account of all the available information it may be estimated that the downthrow of the fault near Pontrhydygroes is at least 1,050 yds. to the north. The base of the Frongoch formation is crossed near the old Logaulas dressing-floors by a fault with a downthrow north of about 130 yds.; what the same fault appears to be is visible in the leat east of the Pengrogywnion brook, where it consists of about 10 ft. of blue clay and dips N.N.E. at about 60° . This is believed to be a branch of the larger fracture, and its displacement has been included in the above estimate. If only the main fault be taken into account, the throw is almost identical with that at Cwmystwyth.

A fault of this magnitude, which we have reason to believe is of later date than the mineralization of the district, must produce a large displacement in any lodes intersected by it, and it is of interest to consider its effect upon the great Comet lode of Cwmystwyth, the average dip of which near Pentre Briwnant is about 65° southward. The Ystwyth fault dips in the opposite

direction at about the same angle and must, therefore, intersect the lode in depth; if we assume a downthrow of 900 yds. there must be a second outcrop of the Comet lode south of the fault, separated from the first by a distance of about 1,000 yds. This is nearly the position of the Logaulas lode, which also dips to the south at about the same angle; the distance between the two outcrops varies from 830 to 1,000 yds. in different places. This close agreement leaves little doubt that the Logaulas lode is the Comet lode repeated on the south of the Ystwyth fault. Some of the old miners who had worked on both maintained that they were the same lode, but having no knowledge of the existence of the Ystwyth fault they supposed that the one was continued into the other without a break. We thus find that the Comet-Logaulas lode is productive at two distinct horizons, viz., near the base of the Frongoch formation and near the base of the Cwmystwyth formation, which are separated by nearly 3,000 ft. of strata in which the lode, so far as is known, is unproductive.

CHAPTER III.

EAST-AND-WEST FAULTS AND LODES—*continued.*

LODES OF MONTGOMERYSHIRE.

The Llanerchyrour Lode derives its name from a hill west of Tyisaf in the Pennant valley, 2 miles south of Llanbrynmair village, and from this locality it can be traced to Rhoswydol, nearly 2 miles to the west. On this hill there are several small lodes, and in order to avoid confusion the name is applied to one that dips to the south at 55° to 65° and can be traced almost continuously from near the summit of Llanerchyrour to Banc Rhoswydol. At the former point is an old shaft and opencast in which a mineralised shatter-belt about 10 yds. wide is visible, ranging south of east; it is bounded on the north by a gossany band, lying on a footwall striking E.N.E. and with a southerly dip of 60° . This opencast is on the junction of the Llanerchyrour lode with a south branch which goes off E.S.E. towards another old shaft about 120 yds. away; the junction appears to be sharply defined in most of the levels down to the deep adit. About 100 yds. farther east is another opencast of considerable length on a joint-lode dipping south at 75° : this diverges at an acute angle from the main lode about 50 yds. west of the opencast. The main lode cannot be traced far east of the junction; it was met in the deep adit about 30 fms. north of the branch, but was not productive. There are thus two branches given off from the lode within a short space, and most of the ore was obtained near, and to the west of, these junctions, the repeated splitting-up having doubtless impoverished the lode. The middle branch strikes about 5° south of east towards Cae Conroy or Tyisaf mine. A quarter of a mile west of the Tyisaf engine-shaft a cross-cut called Morgan's adit, which was driven southward from near the stream, cut at 13 fms. a "branch" dipping at 78° , and another

called Lloyd's adit, 120 yds. farther east, cut a similar branch at 16 to 17 fms. dipping at 70° towards the Tyisaf lode, which was met at 40 fms. from the mouth. The dump from this shows that it was a brecciated lode with "sugary" quartz carrying finely-divided galena. It probably represents the middle branch of Llanerchyr aur, but there is no evidence that it has been worked in that locality. The south branch does not seem to extend far from the junction. West of Llanerchyr aur the main lode can be traced through the opencasts and adits called Cytiau'r Geifr, into a narrow valley and out of this into the valley of the Ceulan, where there was a mine on it of that name. The course of the lode on the slope of each of these valleys is marked by a deep furrow, due partly to surface-workings and partly to erosion. Near Cytiau'r Geifr the lode is several feet wide with a well-defined footwall which dips south at 57° . In the Ceulan valley it appears to contain blende, for there are several heaps of a few tons each of blende-rock lying on the surface near the old road leading to the mine.

On Banc Rhoswydol, less than half a mile from the Ceulan valley, the lode has been extensively worked up to the surface; it is frequently exposed and dips south at 55° to 65° . The material on the dumps from most of the adits, especially the upper ones, yields a fair quantity of blende. The lode has not been identified on the west side of Nant y Fedw, in which the Rhoswydol dressing-floor was situated. On Banc Rhoswydol there is a parallel, almost vertical, joint-lode of small width, and near the old tramroad this is crossed by another 7 to 8 ft. wide, ranging E.S.E. and dipping south about 80° . What is probably the north lode is exposed again on each side of the valley north of the dressing-floors, where it dips southward at a steep angle; both galena and blende occur on the dumps.

South of the Llanerchyr aur lode there are several nearly parallel lodes in the Ceulan valley which were worked at the Brynyfedwen and Ceulan mines; they are all narrow joint-lodes which dip north at 70° to 80° .

There is reason to believe that in this district the chief "makes" of ore were in the neighbourhood of junctions of branches with the main lode; it may be observed also that the branches are of the type of joint-lodes, and invariably have a steeper dip than the main lode. It is probable that the total displacement is not large and is confined mainly to the latter, but it is not possible to determine its amount.

Tyisaf Lode.—This is a lode which strikes about S. 5° W. and dips north at 75° ; it was worked in the Tyisaf or Cae Conroy mine which lies in the Gwestyn formation. Its outcrop is indicated by surface-excavations and trials extending for 200–300 yds. east and west of the engine shaft. It is believed also to be the lode which has been worked at the surface and in a shallow adit in the Frongoch formation at Graiggoch three-quarters of a mile west of Tyisaf and almost due south of the Llanerchyr aur

shaft; its dip there is about 67° . From this point it can be traced westward into the Ceulan valley and has yielded galena in a hard quartzose slaty matrix. Although not a highly productive lode it is noteworthy in having yielded a considerable quantity of galena though traversing the Gwestyn formation. Near the engine-shaft there is a small heap of good blende-rock.

The Dyfnngwm-Dylife Lode-Belt.—In the neighbourhood of Dylife three important lodes have been worked successfully for many years, but as there is some confusion in their naming it will be convenient to describe first the section in the ravine of the River Clywedog, three-quarters of a mile west of Dyfnngwm mine, where the lodes are united and completely exposed (see Pl. XXI. facing p. 154). Below a tributary, which enters from the north a quarter of a mile east of the old Cyfarthfa or Nantddu mine, the Clywedog flows for 400 yds. on the outcrop of a lode, and then turns south across it, affording a magnificent section of the whole of the great lode-belt. The belt is limited on the south by a clearly defined footwall dipping N.N.W. at 65° which is overlain by 25 ft. of shattered and mineralised mudstone, strongly veined with quartz and containing, at about 22 ft. from the footwall, large spots and lenticles of galena. The mudstone is followed by a strongly-marked plane dipping northward at 60° , which has a good deal of blende adhering to it, accompanied by a remarkable layer of finely-broken angular fragments of mudstone, each fragment being coated by a layer of minute quartz-crystals, so that the whole mass resembles a conglomerate. It is succeeded by about 8 ft. of shattered, highly mineralised cavernous rock and a fair quantity of blende; a hole has been put down here in search of galena. This band again is bounded by a plane dipping north, overlain by about 5 ft. of shattered rock which passes into the unbroken country-rock. Thus a width of nearly 40 ft. is exposed, but the strongly-marked planes which traverse it, and the varying character of its different parts, suggest that we are dealing with a composite lode. This is borne out by the behaviour of the lode-belt when it is traced eastward.

Dyfnngwm Lode.—On the brow of the steep slope overlooking the river the south part of the lode separates from the rest, and proceeds along the face of the slope through Dyfnngwm mine towards Pen Dylife, where it has been extensively worked from Dylife. Its outcrop is indicated by numerous opencasts and shafts, and most of the dumps contain galena in association with larger amounts of blende, and some copper-pyrite, cerussite and pyromorphite.

The lode is exposed on the old road from Machynlleth to Llanidloes a short distance east of the tenth milestone, but has not been traced farther in that direction. Although it traverses the Frongoch formation the Gwestyn shales are at no great depth below the surface, and the dumps from the Dyfnngwm mine, derived mainly from the ground in or below the deep adit, consist

of rusty fragments of that formation with crystallised quartz and some calcite. The lode carried a large proportion of blende and some copper-pyrite in association with galena.

Dylife Lodes; Esgairgaled and Llechwedd ddu.—The north part of the lode has been traced by trial-holes almost continuously in a north-easterly direction towards Dylife, but at an old shaft south of the row of cottages known as Rhanc y mynydd, it splits into two branches; the northern branch is the Pencerig or Esgairgaled lode, the southern is the Llechwedd ddu lode.

The chief workings at Dylife were on it and the Dyfngwm lode. Two other lodes, which have scarcely been tried, also outcrop close together about 50 yds. south of the west end of the reservoir, or a quarter of a mile south-west of the church; the northern one dips north and the other, which is only about 10 yds. distant, dips south. Both are several feet wide and filled with breccia, veined with coarsely-crystallised quartz. Two hundred yards west of this point a shaft was sunk on the south-dipping lode to a depth of 15 fms. on a rich pipe of galena. The Llechwedd ddu lode was worked in the shaft of that name (100 fms. deep) and in the Bradford shaft (130 fms.); it dips north at about 80° . It has not been recognised east of Dylife, but may be represented by a conspicuous fracture visible on its line of bearing in the great precipice called Craig y Maes, three-quarters of a mile in that direction.

The Esgairgaled Lode is exposed in the valley north-west of the Bradford shaft to a width of about 15 yds. and dips N. 20° W. at 65° . It consists of shattered rocks and breccia firmly cemented into a hard lode by quartz; it is traversed by several strong planes and carries a large amount of blende. It appears that the upper levels driven from the shaft near the stream yielded galena, but in the deeper levels blende only was found.

A few yards north of the steep path called Llwybr y Ceirw, three-quarters of a mile north-east of Dylife, the precipice is scored by a deep straight and narrow groove which is conspicuous from a great distance. As it is improbable that such a powerful fracture as the lode proves to be near Dylife should die away in a short distance, and this groove, which is almost exactly in the line of the Esgairgaled lode, is the only break or line of weakness in the precipice, there is little doubt that it marks the position of the lode.

The Dyfngwm-Dylife lode thus splits up repeatedly in going east, but it is only near one of these junctions at Dylife that the lodes have proved exceptionally rich. The Dyfngwm lode was most productive at a distance from any junctions and the main mass of ore at Dylife was also some distance away from the point where the lode splits. It is doubtful, therefore, if, in that area at any rate, the deposition of ores has been to any serious extent governed by the occurrence of these junctions.

West of the section in the River Clywedog described above, the river-channel for over 300 yds. has been excavated along the

hanging wall of the lode, while the south slope of the ravine is formed by a towering wall-like mass which is the lode itself; behind it is a depression marking the position of the footwall. It is the finest natural exposure of a lode to be seen in the country. Between this point and Cyfarthfa (Nantddu) mine the lode-belt is many yards in width and several subsidiary fractures which spring out of the lode and rejoin it can be traced. Near the mine the geological effect of the lode can be calculated; the boundaries of the Frongoch and Gwestyn formations are each displaced through about 300 yds., which indicates a downthrow north of about half that amount.

In the mine the dumps consist of hard brecciated quartzose fragments which are rather rich in blende, intermixed with copper-pyrite and some galena, the minerals commonly forming a speckled mixture in the matrix. Dolomite and calcite are, as is usual, associated with the copper-pyrite and occasionally form the binding material of the rock-fragments, which belong to the Gwestyn formation.

From this locality the outcrop can be traced past the north end of Bugeilyn Lake, west of which some trials have been made on it. In one of these a very hard brecciated lode was cut, carrying a fair amount of blende, but no galena. It continues west-south-westwards through the grits and mudstones of the Van formation past a large mass of vein-quartz on Foel uchaf to near Carn Gwilym, where the lode throws down the Upper Van mudstones against Lower Van grits. Some adits have been driven in its course, and in one of them pink-stained shales, such as are usually associated with manganese ores, were found. Beyond this point there is no direct evidence of its outcrop, though many trials have been made on its line of bearing near Hyddgen; in one of these half a mile south of that place a small amount of psilomelane associated with pink-stained shales was found, but it is clear that the main lode cannot pass through that point or, indeed, in any other direction north of this, for the boundaries of the Gwestyn formation can be traced without a break across that tract. The lode appears, therefore, to come to an end near Carn Gwilym, since no displacement of its magnitude can be discovered on its line of strike to the west.

It is interesting to observe, however, that the Camdwr lode can be traced through Cardiganshire as far as Drosgol, and if it maintained its direction eastward it would follow the valley of Afon Hengwm to the south end of Bugeilyn Lake, thus ranging parallel to, but about half a mile south of, the other. The mapping of the geological boundaries shows clearly that there is no displacement on that line, so that the outcrop of the Camdwr lode eastward appears to come to an end in the same locality as the Dyfngwm-Dylife lode westward. Both are wide lodes with a downthrow to the north (150 yds. in one case and over 200 yds. in the other); they have been traced continuously for several miles and are such powerful fractures that it is unlikely that either

will die away rapidly; further, both are associated at certain points with some manganese-ore. These reasons afford strong grounds for identifying the Camdwr lode of Cardiganshire with the Dyfnwgwm-Dylife lode of Montgomeryshire. It may be suggested, therefore, that near Carn Gwilym the outcrop of the latter turns south-westward for about 2 miles along the broad flat-floored valley of Afon Hyddgen and the eastern flank of Banc Llechwedd-mawr to join the Camdwr lode. Numerous small branches that have been detected near Hyddgen are probably related to the swerve in the strike of the main lode.

The Van Lode.—Although this lode was only proved at Van after it had been worked for many years at other points on its course, yet its great productiveness at that mine makes the choice of this name more appropriate than any other. It was first discovered at Van about 1854 by costeaning on the surface near the large quarry east of the mine, but ore was not found until 1862, and the chief mass was only struck in 1865 after continuing for about 150 yds. farther north an adit cross-cut which had been commenced by former searchers.¹ C. le Neve Foster,² in 1879, gave a detailed account of the lode and the method of working it, in a paper to which frequent reference will be made.

For a distance of about 300 yds. east of Edwards' shaft, near Manledd uchaf, the lode strikes about E. 25° N. and dips southwards at about 66° (see Pl. XXII., facing p. 157). East of that point, between the adit and the large quarry, the strike is E. 15° N. and the average dip about 70°, but near the quarry it resumes its former direction. At that point the base of the Gwestyn formation abuts on the lode from the north, but on the south side it is at least 400 yds. farther west; the downthrow caused by the lode being, therefore, about 200 to 250 yds. Near the footpath and stile about 150 yds. north of the quarry there is a small displacement of the same boundary-line, indicating a downthrow south of 10 to 15 yds. This fracture has the same strike as the Van lode farther west, and it must, in fact, form a junction with that lode near the point where its direction alters. This branch acquires some interest because a junction of this kind is observable in the 105-fm. level near the engine-shaft, and is there accompanied by a distinct change in the mineral-content of the lode; but whereas it is impossible to determine the relative downthrows of the two components underground, this can be done at the surface. Foster states that the "filling of the original fissure is composed of three parts: firstly, on the south side, the *flucan* or *soft lode*, secondly, the *bastard lode*, and, thirdly, on the north side, the *regular lode*. The *flucan* is a mass of clay and soft broken-up slate, generally about 12 ft. and occasionally 24 ft. wide. It presents all the appearance of having been formed by the attrition of the side of a fissure

¹ These facts are extracted from Edward Hamer's "Parochial Account of Llanidloes," Lond., 1873, Pt. 1, and 1876, Pt. 2.

² *Trans. Roy. Geol. Soc., Cornwall*, 1879.

in slate-rock. In the deeper parts of the mine the flucan diminishes in width very considerably, and at the bottom level is only a few inches thick.

"The bastard lode is a mass of slate-rock, generally four or five fathoms wide, between the flucan and the regular lode. It is not a hard, solid rock like the true '*country*'; but it is much softer, and it is traversed by numerous little strings and veins of galena. Though as a rule too poor to be worked, it occasionally is very rich, and may even as in some stopes, above the ninety fathoms level, form the most productive part of the lode.

"The galena in the bastard lode usually assumes a largely foliated character (*potter's ore*) whilst that of the regular lode is more granular. Between the bastard lode and the true lode there is generally a wall, or plane of division, and frequently a band of yellowish hornstone, mixed with a little blende, runs along the north side of it. We now come to the regular lode itself. This consists of masses of slate traversed by veins of galena, varying in size from mere strings to *leaders* or branches 1 ft. to 2 ft. wide. With the galena are considerable masses of quartz and blende, besides a little iron-pyrites, marcasite, copper-pyrites and calcite. In several specimens I noticed the succession, 1 quartz, 2 galena, 3 blende, 4 quartz, but I am not sure that this order always holds good. In many places the lode is a true breccia, made up of fragments of slate cemented together by quartz, galena and blende; and it would be difficult to find better instances of brecciated structure than are met with in the Van Mine. The footwall of the regular lode is generally well-marked, and it is often covered with slicken sides dipping west; similar striated surfaces are also found in the joints in the lode itself."

The above description refers to the part of the mine lying near and west of the engine-shaft; it compares in many respects with the section exposed in a cross-cut at the 120-fm. level through the so-called "blende lode" where three distinct parts can be recognised, each of which is similar in general characters to those described by Foster, with the exception that blende predominates over galena. There is, therefore, little doubt, in spite of the difference in strike, that the blende-lode is the true continuation of the main Van lode farther west, as is indicated also by its downthrow on the surface, but that the relative proportions of blende and galena have altered. Mr. Miller suggested to me that the blende-bearing part was a distinct lode which crossed the galena-bearing or true Van lode near the engine-shaft in the 105-fm. level, and that therefore the blende-lode was continued on the same bearing westward from the point of junction, while the Van lode maintained its course and character eastward. This interpretation is based on the sections visible in the 105-fm. level and implies the intersection, without change of strike, of two south-dipping lodes.

At the 105-fm. level the engine shaft intersects the flucan or soft lode, and a cross-cut northward has proved the lode to be 60 ft. wide with blende and some galena disseminated through a breccia cemented by crystalline quartz.

The footwall on the north is well-defined, striking nearly east-and-west and dipping south; a few yards west of the cross-cut it is crossed by another ranging E. 35° to 40° N., which is apparently continued westward into the workings on the Van lode. According to Mr. Miller, these represent the footwalls of the blende-lode and of the Van lode respectively. I have been led to a somewhat different conclusion, viz., that the blende-lode is the true eastward continuation of the lead-bearing Van lode, with the section of which it agrees closely, but that a change in its strike and mineral-content takes place near the junction. At the same time a small branch is given off eastward at that point but probably does not persist far in that direction. It is possible also that a corresponding branch is given off westward which continues the direction of the blende-lode, but there is no question that the main fracture and displacement occur along that part which carries the galena in the western portion and the blende in the eastern portion of the mine. Galena is said to have been found near the outlet of the reservoir, three quarters of a mile west of the mine; there is also some evidence of a slight displacement in the outcrop of the Van grits on the slope farther west, and small excavations have been made along it. Both these points lie on the line of the outcrop of the lode east of the engine-shaft, and may represent a small western branch which would be Mr. Miller's "blende-lode." In the higher levels of the mine the change from galena to blende does not coincide with this junction as it should do if two distinct lodes intersect.

At Van there is also a south lode which has been worked in the deeper levels and has yielded a considerable amount of galena; its strike is parallel to that of the main lode, but it dips south at about 74° ; its relation to the other workings may be discussed more conveniently at a later stage.

In view of the extensive search made for the Van lode at East Van, its course in that direction is of some interest. An adit cross-cut was driven in northwards 300 yds. east of the "old engine-shaft," and appears to have cut a lode at 41 fms. from the mouth. From this point the adit was driven to about 60 fms. west of the old engine-shaft, and from this shaft a 25-fm. level was carried to a point about 34 fms. west of the "new shaft" near the Llanidloes-Machynlleth road, and thus nearly up to the boundary of the Van sett. The combined length of these two levels is over 500 fms., apart from numerous cross cuts to north and south. The position of the lode at the surface can be accurately fixed at two points. Between the new shaft and a lane to the east the base of the Frongoch formation strikes into the lode from the south while on the north the Gwestyn rocks adjoin it for a great distance. In the lane

opposite the cottage called Pwlllyrebol shattered rusty Gwestyn shales are exposed, while farther north similar rocks occur in an undisturbed position; the lode must, therefore, pass through or even perhaps a little to the south of the shattered rocks. On the plan the 25-fm. level is a few feet *north* of this point. Again, in the stream about midway between the above cottage and the old engine-shaft, grey shales on the south are thrown against Gwestyn rocks on the north, thus indicating a considerable downthrow south; the 25-fm. level is here about 50 ft. to the north. Except near the old engine-shaft that level is everywhere north of the outcrop as fixed from surface-evidence.

Further, the 25-fm. level is for some distance vertically under or to the north of the adit. The plan has been carefully made and appears to be accurate so that if the lode followed in the 25-fm. level be supposed to be the Van lode, it must be assumed to have become vertical or even to dip to the north. In view of its consistent southerly downthrow, this is extremely unlikely; it is a more reasonable suggestion that the Van lode lies everywhere south of the 25-fm. level. If at the localities mentioned above the lode had the same dip as near the Van engine-shaft, the 25-fm. level should be about 25 and 30 fms. respectively south of its present position. Near the new shaft and the old engine-shaft a branch was reached in cross-cuts south and followed for some distance; it is about 15 to 25 fms. south of the main level and, therefore, approximately where the Van lode might be expected.

It does not appear that any ore was found in these expensive drivages. It may be observed that the lode here is bounded on the north by the Gwestyn formation and that the same rocks are not far beneath the surface on the downthrow side.

The further course of the lode is unknown, but certain surface-features suggest that it passes under a wet marshy strip at the northern margin of the Glangwden Wood. In that wood there are several short trial adits, but none of them seem to have cut the lode.

West of Van the lode has been worked at Penyclun, where it crosses an anticline which brings up the Lower Van grits to the surface. A small area of the grits in the nose of the anticline is exposed south of the lode where it crosses the road from Llanidloes to Bwlchygle. The exposure is of interest as the grits are in all probability those which form the "flats" in the deeper levels of the Van mine three-quarters of a mile away. It appears that a small south lode was worked at Penyclun at from 20 to 60 yds. south of the main lode. The dumps from the adit east of the farm consist of Van mudstones and some grits, but it is not known whether the flat-formation was found in that mine. The lode-matter is interesting in that the galena is associated with barytes.

A short distance west of Penyclun is the small Glyn mine in the Upper Van mudstones; the lode was cut in the shaft at a depth of 50 fms.

The much larger Bryntail mine adjoins Glyn on the west. In Merry's shaft east of the farmhouse galena is associated with pure, massive and saccharoidal witherite and some barytes; some pieces are drusy and exhibit crystalline forms, though the crystals are small and closely packed.

A deposit of barytes about 40 fms. in length was worked by the side of the road west of the farmhouse; it appears to have been several yards wide, but was almost confined to a depth of a few fathoms below the surface, and is said to have been largely taken away.

Near the River Clywedog the footwall of the lode, dipping S.S.E. at about 70° , is exposed in the mouth of the adit near the old dressing-floors, where a considerable quantity of barytes was treated at one time.

On the slope west of the river several adits enter the lode; the upper one was driven into a "north lode" or branch which outcrops about 30 yds. to the north of the main lode. Barytes and witherite are associated with galena in some of the dumps and is the most westerly point at which these minerals have been found.

It thus appears that the barium-minerals are confined within a length of about a mile and a half along the outcrop of the lode. They occur in short bunches and are found mainly near the surface; the largest deposit was that at Bryntail near the middle of their range. It may be observed that this district lies on the axis of the main anticline which brings the Van grits and mudstones to the surface, and that the rocks traversed by the lode between Penyclun and the slope west of the Clywedog belong on the whole to a lower horizon than any which outcrops east of the Plynlimon range. Possibly this fact has a bearing upon the limitation of the minerals to this area.

About half a mile west of the Clywedog is Aberdaunant mine, where the lode has been reached and worked from several adits and cross-cuts. A few yards north of its outcrop a strong, almost vertical fissure has yielded some rich masses of galena where it crosses the uppermost grits of the Lower Van formation. On the dumps from the workings there are considerable amounts of cerussite, and fragments of grit are abundantly coated with pyromorphite. Large crystals of galena are completely covered with a layer of hydrated oxide of iron, about one thirtieth of an inch thick. This "north lode" appears to be restricted to this spot.

West of Aberdaunant the lode leaves the Van formation and traverses a wide area of the Gwestyn rocks, in the middle of which lies the old abandoned Gwestyn mine, after which the formation has been named; some galena and a fair amount of blende may be found on the dumps. The lode has produced a

downtthrow south of about 200 yds. where it crosses the base of the formation.

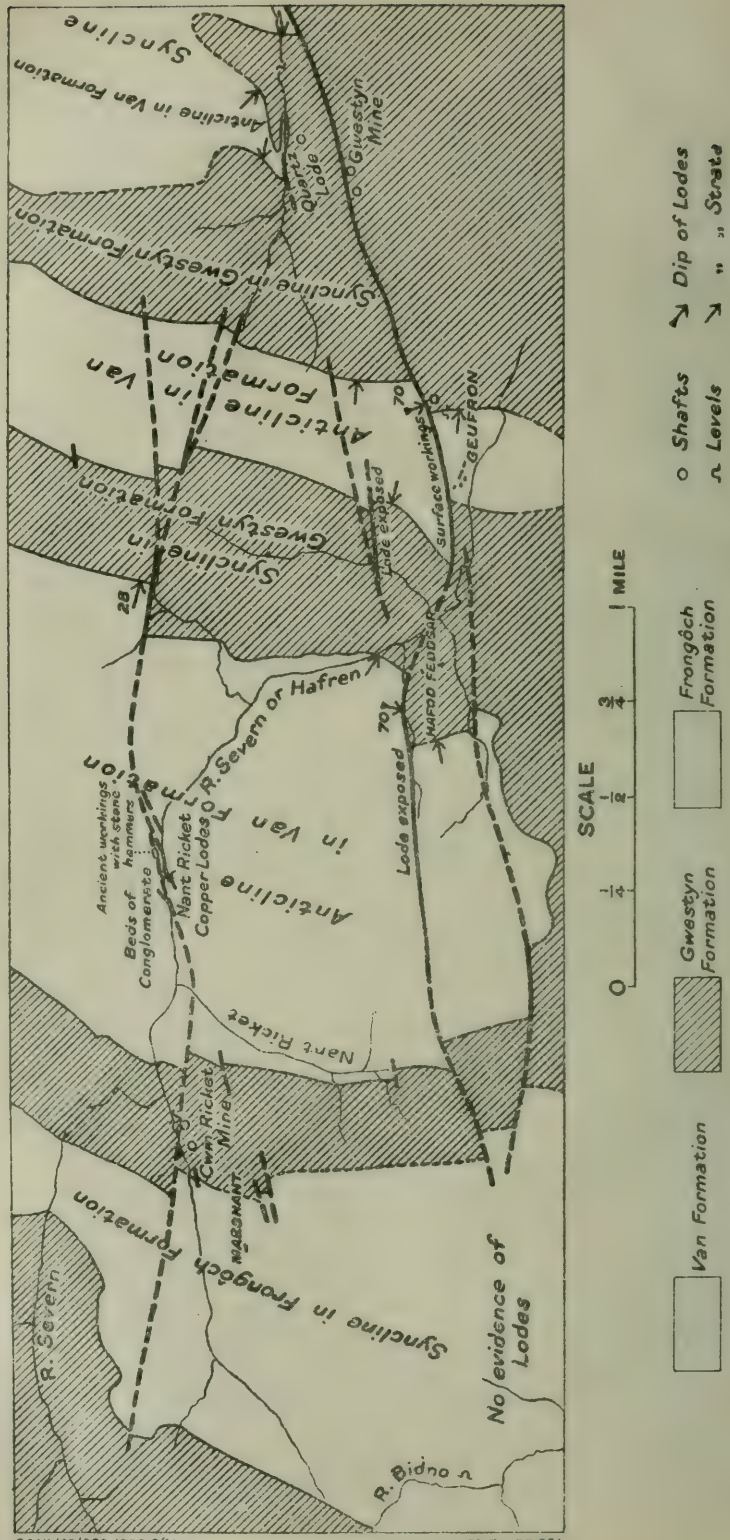
At Geufron mine, north of the Severn (or Hafren), copper-pyrite with malachite and iron-pyrite, associated with calcite and chalybite, are fairly abundant constituents, and copper-pyrite was worked for many years. The workings lie in the lower beds of the Gwestyn formation, the base of which is thrown down 150 to 200 yds. south by the lode.

West of this point the fracture breaks into two branches, and it is not certain which should be regarded as the main lode. The northern branch, which is named after Hafodfeddgar farm, is exposed for a long distance in the ravine north of the house, and has been tried in an adit. It dips at 70° and throws down the base of the Gwestyn rocks 100 to 150 yds. to the south. It is a wide brecciated lode, similar in character to that at Geufron, but contains more galena associated with rather abundant cerussite. The other branch is about 300 yds. farther south and strikes towards the lode east of Geufron. It is, on the whole, a downturn south of 50 to 100 yds., but its existence does not appear to have been known as there are no trials anywhere on its course. The vertical displacement is accompanied by some horizontal movement of the hanging wall eastwards. The Hafodfeddgar branch represents more nearly the characteristics of the Van lode and is certainly continuous with it, although a considerable swerve to the north occurs in crossing the Severn valley. The other branch is probably an off-shoot from the main lode at the point of deflection near Geufron. In the stream half a mile east of the Hafodfeddgar adit there is a lode which strikes towards that level; where it crosses the base of the Gwestyn formation it has a downturn of a few yards only, and as it lies on the strike of the Hafodfeddgar lode there is little doubt that it is a branch thrown off from the main lode at the point of deflection west of the Severn valley.

These two main lodes converge westward, but owing to the absence of exposures neither can be traced beyond a point about a mile and a half west of Hafodfeddgar, where, however, their combined effect is a downturn to the south at least as great as along any part of the outcrop. Direct evidence of the existence of the Van lode ceases therefore in that locality, but in view of the magnitude of the displacement produced by it there can be no doubt that it persists for a considerable distance to the west.

In the Wye valley, near the old mines of that name, there is a powerful southerly downturn which affects the base of the Frongoch formation. A number of lodes have been exploited in that locality, but in the absence of plans, it is impossible to say whether any of the workings are on the main displacement, which appears to strike towards the point where the Van lode was last recognised.

West of these mines a powerful fracture affecting the basal beds of the Frongoch formation is visible in the ravine near the



GEOLOGICAL MAP OF DISTRICT AROUND GEUFRON AND NANT Y RICKET.

ford over Nant Cyff. It is associated with numerous subsidiary fractures, which are probably related to an abrupt change in the strike of the lode. A mile to the south-west some trials have been made near the Aberystwyth-Llanidloes road, on a wide brecciated lode, dipping south-east, but this is certainly not the main branch, for its displacement is insignificant. In the River Tarenig, 70 yds. below a small tributary which enters from the south, there is, however, a fault 4 to 5 ft. wide with a large southerly downthrow which must be regarded as the main part of the lode. It crosses the hill south-westward in the direction of Cwmergyr, where the Castell lode has been identified. Although there is a tract of nearly 2 miles in width east of the Wye Valley mines, across which no lode can be traced for lack of rock-exposures, yet there is no reason to doubt that the Van lode of Montgomeryshire is continued across that space into the Castell lode of Cardiganshire.

Nantyricket Lode.—In the bed of the Severn, about a mile above Hafodfeddgar, a powerful belt of fracturing traverses Lower Van grits and conglomerates which lie on the axis of the anticline of Mynyddygroes. One of these fractures, which may be called the Nantyricket lode, contains copper-pyrite and calcite, and has been worked for copper-ore. It strikes from the river up the steep slope to the east, and nearly a mile in that direction crosses from the Van into the Gwestyn rocks, the boundary-line being displaced by a southerly downthrow of about 120 yds. A short distance to the east it splits into two branches, the northern having a downthrow of about 20 yds., and the southern of about 30 yds., both to the south. The latter immediately splits again into two small fractures each of less than 10 yds. downthrow. Half a mile farther east, near the stream north of the Gwestyn mine, one of these is joined by a part of the branch from the Hafodfeddgar lode. A considerable width of coarsely brecciated quartz has recently been exposed here, but the throw is insignificant. Here, therefore, we have evidence of a large displacement diminishing progressively eastward and dying away almost completely in a distance of less than 2 miles (*see* Pl. VIII.).

West of Nantyricket the same changes may be observed. One of the branches has been worked at Maesnant; west of that mine it causes a southerly downthrow of 70–80 yds. in the base of the Frongoch formation. One or more other branches are given off in a west-south-westerly direction, and it is possibly one of these which has been worked in the upper mine in the Wye valley (Nantygwrdd). The combined effect of all these displacements near Maesnant is less than in the river, and about three-quarters of a mile to the west the Maesnant branch has almost ceased to exist. From the fact that the downthrow is at a maximum where the lode-belt crosses the anticlinal axis and diminishes both east and west, it may be inferred that the fracture is contemporaneous with the folding. This, in turn, suggests an early date for the mineralisation of the district.

CHAPTER IV.

DETAILED DESCRIPTION OF THE MINES.

CARDIGANSHIRE MINES WITH A TOTAL OUTPUT,
SINCE 1845, OF ABOUT 1,000 TONS OR OVER.

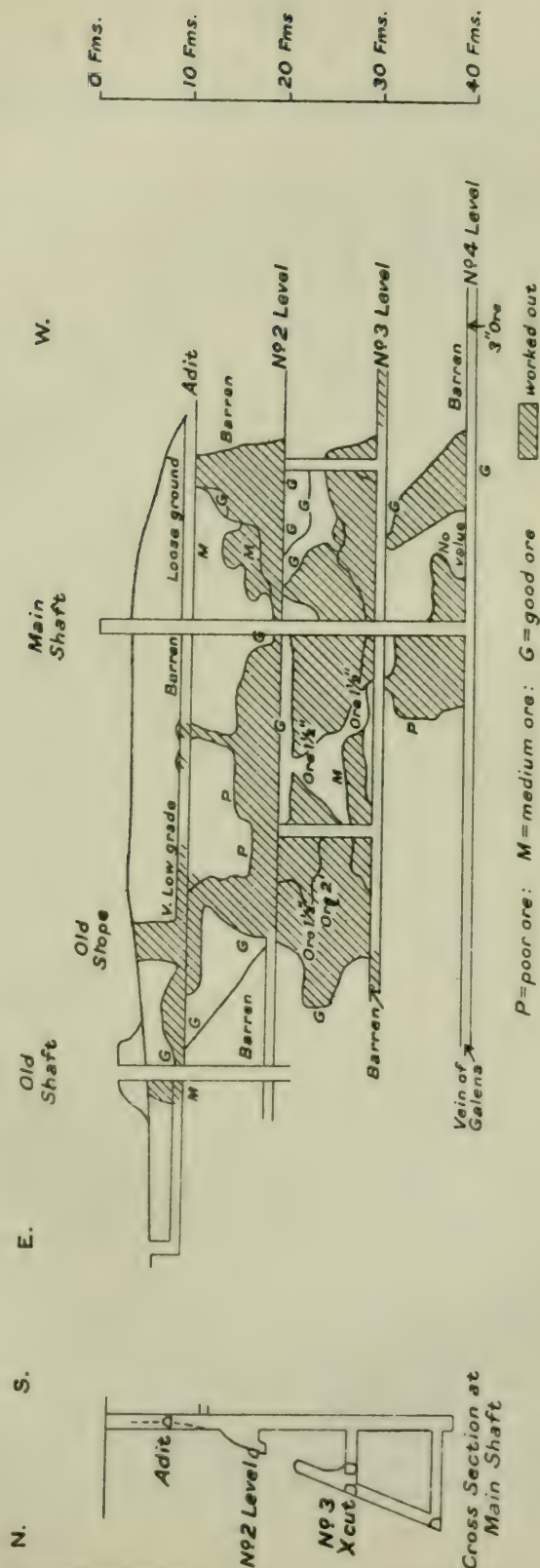
LOVEDEN OR PENRHYNGERWIN.

(6-in. Sheets, Card. 1 S.E. and 2 S.W., Long. $3^{\circ} 57' 45''$,
Lat. $52^{\circ} 31' 38''$.)

This is a small mine near the main road to Aberystwyth, $2\frac{1}{2}$ miles south of Glandovey. The lode dips about E. 25° N. at 70° and is a normal fault with a downthrow of about 50 yds. The rocks traversed by it at the mine are the upper beds of the Van formation, folded into a sharp anticline; on each side of their outcrop the lode enters the Gwestyn formation, but can only be traced in either direction a short distance beyond the limits of the workings. The galena occurs in branches and narrow strings, associated with abundant calcite as the principal lode-filling.

A vertical shaft, from which the mine was worked, was sunk to a depth of about 36 fms. from the surface, or about 30 fms. below a shallow adit; it is too far south for economic working at a depth, as each succeeding level will require an increasing length of cross-cut to reach the lode. The lode was intersected in the adit, and cross-cuts north were driven to it at about 10 (No. 2 level), 20 (No. 3), and 30 fms. (No. 4). The adit and levels are from 70 to 90 fms. long, and ore was obtained in each, the most continuous body being that between the adit and No. 3 levels, where it was about 55 fms. long, about 16 fms. high and $1\frac{1}{2}$ to 3 in. wide. The average width of ore throughout the part that has been stoped is just over 2 in. In the bottom level ore was found for about 30 fms. near the shaft at the east end and again near the west end. This has not been taken away (Pl. IX).

The limited extent of the workings renders it impossible to draw any conclusions as to the prospects of the mine at a greater depth. If the galena which has been exposed at the east end of No. 4 level proves to be of some extent an increasing length of the ore-body as compared with the upper levels is indicated; on the other hand, it may be a sporadic occurrence. Miners who have worked in the mine regard the east end with more favour than the west end. All the workings which have been carried out hitherto lie on the west side of the anticlinal axis.



LONGITUDINAL SECTION OF LOVEDEN MINE.

Output.

Lead-ore was returned in the years 1854, 1855, 1859, 1901-05, 1908-11 :—

Lead Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Metal.	Blende.
Tons. 997	Tons. 769	% 77·1	Oz. 2,145 ¹	Oz. 9·3	Oz. 12	Tons. 5

¹ The amount of silver contained in the whole of the ore may be estimated at 9,200 oz.

ESGAIRHIR AND ESGAIRFRAITH OR CAMBRIAN OR
CARDIGAN CONSOLIDATED.

(Esgairhir, 6-in. Sheet, Card. 4 N.E., Long. 3° 52' 10",
Lat. 52° 30' 15".)

These two mines acquired much renown as a result of various reports published by Waller between 1698 and 1700. In a plan of Esgairhir accompanying "An Essay on the Present State of the Mines, late of Sir Carberry Price," published in 1698, six veins of lead-ore of a total width of 30 ft., and two veins of copper-ore, are shown running parallel to one another and at a small distance apart, and in a description accompanying a later plan published about 1700, further details are added. The largest vein was 11 ft. wide, "but that in ore never exceeded 7 ft. 6 in.;" another vein near to it was "in places about 8 ft. wide in firm solid ore," which was raised and washed at 3s. 7d. per ton. In another parallel vein, the ore was a yard wide. An adit had been driven some distance from the east to unwater workings commenced at various points on the surface.

In this and a previous essay, Waller demonstrated that with the help of 600 men and a sufficient stock the mine would yield an annual profit from the lead-ore alone of 70,500*l*. For this reason he compared the riches to be obtained from it with those of Potosi, and described the row of miners' houses which had then been erected as the "new town called Welsh Potosi" (now called the Barracks). In view of these surprising computations, made apparently in good faith, the subsequent history of the mine is of some interest.

It was in connection with Esgairhir that Sir Carberry Pryse, in conjunction with some others, procured in 1693 an Act of Parliament (5th of William and Mary), whereby the Crown relinquished its claim to the mines of the country "notwithstanding they contained gold and silver," but retained the right of buying the ore upon the bank at a fixed price of 9*l*. a ton for lead and 10*l*. a ton for copper. The mine was worked intermittently until about 1744, after which there is no further infor-

mation for about a century, though, together with the adjoining mine Esgairfraith, it is recorded by Meyrick as in active working in 1810.

As the Esgairhir and Esgairfraith workings are not connected, it is convenient to describe them separately. A plan and section of Esgairhir is preserved in the Home Office; the only plan of Esgairfraith which has been seen is one in the Gogerddan Estate Office (dated 1884).

Esgairhir is drained by an adit (about 1350 O.D.), the mouth of which is south of a small reservoir near the dressing-floors; it intersects the lode about 135 fms. to the west-north-west, near the point where the road crosses the stream (*see* Pl. IV. facing p. 20). From there it has been driven on the main lode or one of its branches to the marshy tract near the barracks, where it appears at the surface at about 1360 O.D., being, therefore, open at both ends. The western entrance served as a road for the miners to enter and leave the mine. This is probably the adit which was being driven under Waller's superintendence in 1698. From the surface to the adit a large number of shafts were sunk; no less than 18 are shown on the vertical section of the mine preserved in the Home Office. Some of these were possibly for ventilation, but most were required for access to the ore-bodies, the distribution of which is unlike that of any other mine in the area. Lead-ore was originally found up to the turf in various places along the outcrop, and at those points a shaft has been sunk.

About 100 yds. west of the ruined smithy and other buildings the Whimsey shaft was sunk to 30 fms. below the adit, and about 120 yds. west-north-west an engine-shaft was sunk vertically to the depth required for a 30-fm. level, and a cross-cut south was driven to the lode. The position of this shaft (about 100 yds. north of the outcrop) suggests that it was intended to cut the lode at a depth of 90 to 100 fms., but it does not appear that it was carried below the 30-fm. level.

The 10-, 20- and 30-fm. levels are from 70 to 100 fms. long, so that comparatively little ground has been opened up below the adit. It would seem, both from the stoped areas shown on the section and the accounts of men who worked in the mine, that the ground below the adit, and especially below the 10-fm. level, contained only short bunches, which proved unreliable. They appear to have been rich occasionally, but, as one of the miners expressed it, "there was nothing with any heart in it." The character of the ground below the adit does not seem to have encouraged sinking the mine to a greater depth.

The productive ground lay between the large opencast near the smithy and a point on the road about a quarter of a mile to the west, and extended from the surface to the adit and in some cases below, but there is no evidence that much ore was got from the 30-fm. level. Within these limits

the ore was found in vertical shoots, each narrowing downwards and separated from its neighbours by barren ground; having regard to their peculiar form they may suitably be termed "pipes."

It is probable, however, that these pipes were very rich, for most of the output of the mine since 1845 (2,675 tons) seems to have been derived from the pipe opposite the smithy, which was only about 13 fms. wide, and 65 fms. high; the average yield of dressed ore was, therefore, over 3 tons per square fathom in the stopes. If account is taken of the usual losses in recovery, the actual content of ore in the lode may have been 4 tons or more per square fathom, or, approximately, 20 per cent. So far as information can be obtained nowadays, the ore-bodies had the form of a double wedge, wide in places but rapidly narrowing. Waller, in estimating the profits to be made, assumed that the ore which had then been proved at only a few points, maintained its width throughout the mine. It is clear, however, that a large amount of ore had been got before returns were made in 1845, and it is not unlikely that altogether from 10,000 to 20,000 tons of lead-ore have been obtained from the mine. It is noticeable that most of these pipes occur at points where a considerable change in the strike of the lode takes place; throughout the productive belt several violent changes of strike of from 40° to 60° within a distance of a few fathoms are indicated on the plans. Probably the rocks at such points are more fissured than elsewhere, and if lateral movement accompanied the vertical downthrow, as is likely, open cavities of a pipe-like form favourable to the deposition of great masses of ore would result.

In view of its reputation as a silver-lead mine, the silver content is unexpectedly low. The returns are far from complete, but, taking the 13 years between 1884 and 1903 for which returns of silver are available, the average content is 7 oz. per ton of ore, or about 9 oz. per ton of lead. Waller estimated that the silver was worth about 14*l.* per ton of metal, which, at the then price of silver (5*s.* 6*d.* per oz.), represented about 51 oz. or about 38 oz. per ton of ore. In 1700 he admits, however, that the Esgairhir ore was not as rich in silver as others in the country. Moreover, in an abstract of accounts he rendered to the Company of Mine Adventurers in 1700, we find that 72·3 tons of lead refined at Neath, yielded 660 oz. of silver, or about 9·1 oz. per ton. The source of the ore is not mentioned, but it was probably Esgairhir; the other ores then being raised by Waller contained a much larger quantity of silver. There is no clear evidence, therefore, that the lead-ore found near the surface contained appreciably more silver than that at a greater depth. This point has a bearing on the possible secondary enrichment of the ore-bodies.

Esgairfraith, which is half a mile east of Esgairhir, has been worked separately at times, but, as a rule, has been united with

the latter under the names of Welsh Potosi, Cardigan Consolidated or Cambrian mines. Most of its produce was copper-ore, obtained from a shaft sunk on the underlie of the lode to a depth of 126 yds.¹ below the shallow adit, which is about 32 yds. from the surface at the shaft. Levels were driven at 20, 46, 70, 86, 106 and 126 yds.; the ground to the 46-yd. level is drained by a deep adit cross-cut, the mouth of which is about 80 yds. north of the great waterwheel and at about 1320 O.D. The levels have been driven mainly to the east of the shaft, but the longest (in 1884) only extends about 50 fms. in that direction, and, judging by the limited output, not much ground has been opened up since that date. The payable ore-ground forms almost vertical shoots about 4 to 6 fms. wide, somewhat irregularly distributed and separated by considerable lengths of unproductive ground.

As at Esgairhir, the strike of the lode near the mine is subject to rapid changes. The average produce of the copper-ore raised between 1860 and 1904 was about 12 per cent.

Output.

The returns from these two mines have been separated, so far as possible, but it is not always clear whether one only or both mines were responsible for the given output. Most of the copper was probably obtained from Esgairfraith.

Returns are available for Esgairhir in the years 1845-48, 1851, 1854-58, 1860-64, 1868, 1872-75, 1889, 1891, 1896, 1898-1900, 1903, or 27 years in all. The highest output was 516 tons in 1856. For Esgairfraith they are available for 1851, 1878, 1879, 1881, 1883, 1886, 1902-04, or 9 years in all. Average annual output: Esgairhir, about 100 tons; Esgairfraith, about 16 tons:—

—	Lead-Ore.	Lead.	Ratio.	Silver	Silver per ton of Ore.	Silver per ton of Lead.
	Tons.	Tons.	%	Oz.	Oz.	Oz.
Esgairhir -	2,675	1,964	73·4	14,256 ²	6·9	9·2
Esgairfraith -	144	102·7	71·3	334 ³	9·8	13·8

Copper-ore, probably from Esgairfraith alone. About 50 tons were returned between 1837 and 1840. Since the latter year,

¹ The levels on the plan and section are all designated in yards.

² The amount of silver in the whole of the ore may be estimated at 18,295 oz.

³ The amount of silver in the whole of the ore may be estimated at 1,414 oz.

copper-ore has been returned in the years 1860-66, 1877-83, 1885, 1886, 1900-04 (21 years):—

Copper-ore.	Fine Copper.	Yield.	Approximate Value at Mine.
Tons. 2,690	Tons. 319½	Per cent. 11·9	£ 22,648

Highest output, 400 tons yielding 40 tons of copper (1880).
Highest yield of copper, 44 tons from 294 tons of ore (1882).

ALLTYCRIB, TALYBONT.

(6-in. Sheet, Card. 3 N.E., Long. 3° 59' 10", Lat. 52° 29' 10".)

This is one of the oldest mines in the district and the workings are undoubtedly very extensive; unfortunately, it has not been possible to discover the plan which was in existence when the mine was last working in 1913. The following information has been obtained from working miners and from two reports, one made in 1899 and the other about 1912.

There are two north-dipping lodes which cross the hill called Alltycrib on parallel courses, and at a distance apart of about 100 yds.; these may be named the north and the south lodes.

The north lode has been worked extensively in a large open-cast on the brow of the hill overlooking the village, and in a shaft called Child's shaft (or shaft Plentyn), near the edge of the wood about 200 yds. to the west. The ground was drained by a deep adit (about 170 O.D.), which was driven westward from the River Ceulan due east of Capel Nazareth, and, after intersecting the lode, was continued under Child's shaft to the boundary of the wood. The shaft is sunk to a depth of about 20 fms. below the deep adit, where there were stopes, about 16 fms. in length, yielding good ore; it does not appear that this lode has been tried on Banc Tyhen, which adjoins Alltycrib Wood on the west. It may be assumed that the ore above the adit, and for 20 fms. below it near Child's shaft, has been taken away. At the surface there is evidence of many branches diverging from the north lode, but nothing is known of the extent to which these have been explored underground.

The south lode has been worked at its outcrop, mainly near the western edge of Alltycrib Wood and is well exposed in shafts and levels on Banc Tyhen. It has also been intersected by several shallow crosscuts, of which the principal is Wilkins's level (350 O.D.), about 12 fms. below the surface. This adit has been driven a considerable distance east and west and it is said that large quantities of potters' ore were obtained from the lode above it.

In recent years another cross-cut known as Pryse's tunnel (about 250 O.D.) was driven northward from the southern edge

of Alltycrib Wood, near the cart road to Talybont. It was expected to intersect the lode in about 110 fms., but although driven to a sufficient distance, it did not find the ore-body that was worked in the upper levels.

Between Wilkins's level and Pryse's tunnel there are said to be two other drives, No. 1, which is 37 ft. below Wilkins's level, and No. 2, 87 ft. below that level. In the report which contains these figures, the depth of Pryse's tunnel below Wilkins's level is given as 157 ft., whereas it cannot exceed 140 ft. and is probably not more than 130 ft. In No. 2 level the lode was productive, but in Pryse's tunnel it was ill-defined, and the ore was scattered through a considerable width of ground, even occurring in places on both sides of a well-marked wall. It appears, therefore, that the ore becomes dispersed in depth. The yield of the ground in and above No. 2 drive was estimated (in 1912) as being equal to an average width of $1\frac{1}{2}$ in. of galena or 1 ton per square fathom; the amount actually present was presumably higher than this figure as allowance was made for loss in recovery.

Cwm Leri Lode.—This lode crosses the River Leri nearly half a mile below Talybont and strikes north-west towards Banc Tyhen. Three adits have been driven on it from Alltycrib Wood, No. 1 (about 430 O.D.), No. 2 (about 350 O.D.), and No. 3 (about 260 O.D.). The lode was rich above No. 1 and between No. 1 and No. 2, but yielded nothing in No. 3.

Output.

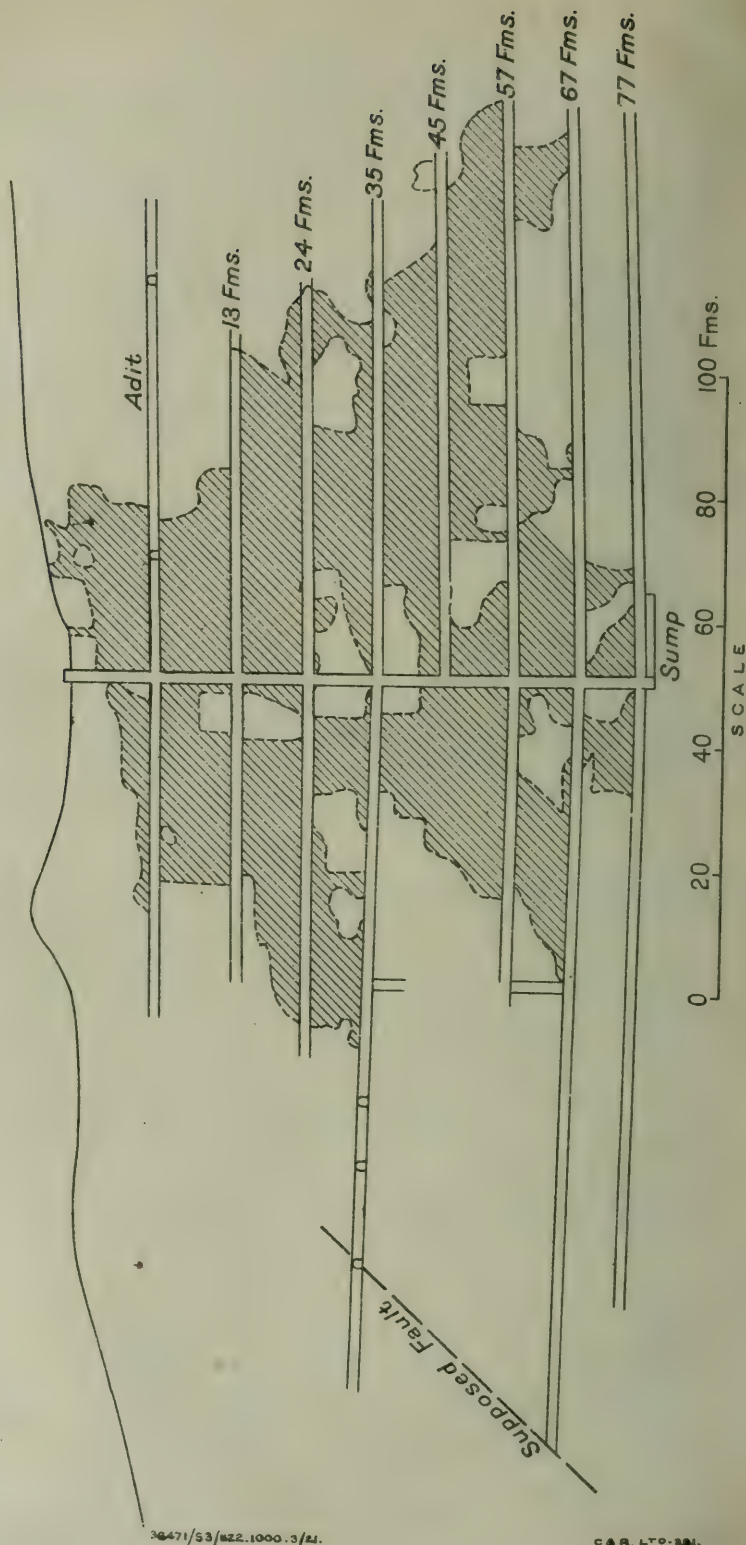
Returns for Alltycrib or Talybont mine with Alltycrib North are given in the years 1845, 1851, 1852, 1858, 1860–65, 1870–73, 1875–80, 1886–90, 1907, 1911–14.

It is possible that some of the Talybont returns include ore derived from the Tanyralit mine, which lies on the same ridge about half a mile to the north. From this mine separate returns are given in the years 1869–71, 1874–86.

In 1882 there is also a return from the North Cardigan mine, which is said to be one of the Talybont group.

—	Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
	Tons.		%	Oz.	Oz.	Oz.
Alltycrib -	1,335 $\frac{1}{4}$	1,009 $\frac{1}{2}$	75·6	6,012	7·58	9·95
Tanyralit -	749 $\frac{1}{2}$	554	73·8	3,966	5·53	7·47
Alltycrib N. -	150	109 $\frac{1}{2}$	73·0	1,243	8·3	11·35
N. Cardigan -	45	36 $\frac{1}{2}$	81·1	365	8·1	10·0
Total -	2,279 $\frac{3}{4}$	1,709 $\frac{1}{2}$	75·0	11,586 ¹	—	—

¹ The amount of silver contained in the whole of the ore may be estimated at 15,834 oz.



LONGITUDINAL SECTION OF BRYNRYAFAR MINE.

Blende.—10 tons were returned from Alltyerib in 1873.

Copper-ore.— $2\frac{3}{4}$ tons were returned from Talybont in 1857.

BRYNYRAFR.

(6-in. Sheets, Card. 4 S.E., Long. $3^{\circ} 50' 50''$, Lat. $52^{\circ} 28' 25''$.)

Brynyrafr mine lies in the Van formation near the Camdwr stream, about 1 mile above its junction with the River Rheidol. In a direct line it is $5\frac{1}{2}$ miles E. by S. of Talybont, but by road it is about 8 miles from that place, and 11 miles from Llandre station on the Cambrian Railway.

It has been worked mainly from a pumping- and drawing-shaft, which is sunk on the lode to a depth of 77 fms. (*see* Pl. X.): the pump was operated by a large waterwheel near the river, and a line of rods about 400 yds. long. A shallow adit cross-cut (about 1085 O.D.) enters the hill 150 yds. south of the shaft, and intersects the lode 20 fms. east of it, draining the ground to a depth of 15 fms. below the surface. Levels have been driven east and west at 13, 24, 35, 45, 57, 67 and 77 fms. A few years ago a new shaft was sunk about 100 yds. west of the pumping-shaft into a part of the mine where little work had been done.

The ore-body, so far as it has been explored, increases in length from the surface to the lowest level (*see* Pl. X.); at the adit about 65 fms. have been stoped and at the 35-fm. level, 125 fms. About 94 fms. west of the shaft the lode is heaved about 5 fms. to the north by a cross-fault; west of this point it contains a fair amount of blende as far as the level has been driven. At the 67-fm. level the lode carries blende and galena for a length of 200 fms.; some of it is of low grade and would hardly pay for stoping unless prices ruled high. In other places it carries blende. The end of the level is barren; it is supposed that the lode is disturbed and heaved by the cross-fault dipping to the west which was proved in the 35-fm. level. The 77-fm. level has been driven a distance of 105 fms. east and the same distance west of the shaft, all the way, except for some low-grade patches, in ore, and a winze a few fathoms west of the shaft found good ore in the bottom of the level. East of the shaft the ore consists mainly of blende, while to the west it contains some galena. At the west end of the level a part of the lode yielded rich lead- and zinc-ore.

It is said that in driving eastward beds of grit were encountered which almost pinched out the lode; these belong to the Lower Van formation and may be expected to increase in number with depth.

Between the surface and the 77-fm. level there are no considerable reserves, and for further development of the mine the shaft must be deepened, for the form of the ore-body favours the opinion that the productive ground will increase still further in length at a greater depth. There are, however, two considerations to be borne in mind: opening up deeper levels will

entail higher working expenses. Hitherto the ore has been drawn by engine-power, and as the mine is not near a railway this is a serious item. If some of the water-power with which the district is well provided could be developed, this charge might be diminished.

The other consideration is the possible influence of beds of grit on the lode. The shaft appears to have been sunk near the crest of an anticline, and at the greater depths the grit-beds will occupy an increasing length of the levels. Whether this is likely to prove an advantage or otherwise it is impossible to say without better knowledge of the ground already worked. In some circumstances such hard beds are highly productive; in others they have an adverse effect upon the lode.

In addition to blende and galena the lode contains in places a considerable amount of marcasite and iron-pyrite.

Output.

Except in the year 1909 the mine was in continuous operation from 1881 to 1912 (31 years). For the purposes of comparing the ratio of blende to galena, the output of each is given for groups of years:—

—	Lead-Ore.	Lead.	Ratio.	Blende.	Zinc.	Ratio.	Ratio of Blende to Galena.	Average Price of Blende.
	Tons.	Tons.	%	Tons.	Tons.	%		Pounds per ton.
1881-5 . . .	577	442	76·6	734	266 ¹	36·2	1·27	3·31
1886-90 . . .	1,373	1,026	74·8	2,040	713	35·0	1·49	3·29
1891-5 . . .	971	743	76·5	780	269	34·5	·8	2·4
1896-1900 . . .	1,074	812	75·6	2,486	880	35·4	2·31	4·31
1901-5 . . .	788	605	76·8	1,675	565	33·7	2·13	3·52
1906-8; 10-12 . . .	169	128	75·7	401	141	35·2	2·37	5·96
Totals and averages	4,952	3,756	75·8	8,116	2,834	34·9	1·64	3·7

¹ In 1881 the returns include estimates of 104 tons of zinc available from 173 tons of ore, and in 1882 of 49 tons from 95 tons of ore. These figures are clearly in error, and have been corrected to 60 and 33 respectively.

Silver returned from 1887-91 was 4,229 oz. (or 3 oz. to the ton of lead), and in 1898, 2,657 oz. (or 12 oz. to the ton). The amount of silver contained in the whole of the ore may be estimated at 6,886 oz.

On the average the proportion of recovered blende to galena is as 5 to 3, but the ratio is higher in the later periods than in the earlier, from which it may be inferred that blende becomes relatively more abundant in the deeper levels. In the years 1891-5 the galena appears to have been more abundant than blende. This is probably to be explained by the low price of blende which ruled during those years, and owing to the same

time to the low price of galena the ore was probably selected so as to give as high a percentage of lead as possible.

In fact, the average ratio of blende to galena, in addition to its general upward rise, shows fluctuations corresponding to fluctuations in price. These considerations are of importance in relation to the possibilities of the mine at a greater depth.

BWLCHGLAS.

(6-in. Sheet, Card. 4 S.W., Long. $3^{\circ} 54' 0''$, Lat. $52^{\circ} 28' 20''$.)

This mine lies on the south slope of the valley called Cwm Tynant, which leads down to Talybont. The nearest station is Llandre, which is 8 miles away. Some years ago a light railway was laid from that station through Talybont and passing Bwlchglas to the mine and quarries at Hafan. This line was, however, dismantled after it had been almost completed.

The mine is worked mainly from two cross-cuts driven southward to intersect the lodes. The East shaft and the West shaft communicated with the surface from the upper cross-cut, and another old shaft was sunk from the lower adit to a 35-fm. level. In recent years the mine below this adit was worked from the Main shaft, which is a vertical shaft to the 35-fm. level about 23 fms. west of the cross-cut. The stuff was drawn along the lower adit and near its mouth was elevated through a vertical shaft to the level of the crusher-bin.

The rocks in the neighbourhood of the mine belong to the lower part of the Frongoch formation. The Gwestyn shales are exposed about 400 yds. west of the mine, and on each side of the valley a narrow outcrop of Van rocks occurs below them in the core of a sharp anticline.

Ore has been obtained at various points of the mine, but the relation of the ore-bodies to one another has not been clearly proved. The workings lie to the south of the Hafan or District lode, which has been met in several parts of the mine, but has not hitherto been productive.

Between the upper adit (about 840 O.D.) and the surface most of the ore has been obtained from Evans's lode, which outcrops at the top of the East shaft, dips steeply to the north and ranges a few degrees north of east. The lode is made up of a close system of joints accompanied by considerable shattering of the rocks; it carries narrow veins and strings of almost pure galena. A winze has been sunk to a depth of 56 ft. below the upper adit near the cross-cut, but the ore becomes scattered downward and the lode proves unproductive. East of the cross-cut Evans's lode converges towards the "Main lode," but the ground is too disturbed to enable the relation of the lodes to be determined. West of the cross-cut a vein of galena, 1 to 5 in. wide, has been stoped away above the level for about 11 fms., but a little further the joint along which it occurs disappears completely. Evans's lode appears, therefore, to be restricted to

the neighbourhood of its junction with the main lode; it has not been proved in the lower adit.

The "Main lode" appears to be that got in the shaft below the lower adit, and is possibly also the one which has been stoped in the upper adit near the West shaft, and, again, about 15 fms. to the west where it has been got in the adit and in a drift a few fathoms below. It dips to the south at from 70° to 80° and is, in places, a strong lode consisting of a mixture of crystallized quartz with spots and veins of galena.

In the lower adit also, a vein of galena dipping north at 60° to 70° has been stoped for a few fathoms in the neighbourhood of the cross-cut. The adit has been driven on it but the vein dies away before reaching the Main shaft. This is distinct from Evans's lode and lies about 10 to 15 fms. to the north of it.

The Hafan or District Lode.—In the top adit two strong fissures, ranging due east and west and dipping to the south at 70° and 74° , were intersected at 22 and 32 fms. from the mouth. Similar fractures were cut in the lower adit at 103 and 114 fms. from the mouth. From their position there is no doubt that they are continuous with those in the top adit, and they agree closely with the outcrop position of the District lode.

None of these fissures show any signs of ore.

In the top adit, at about 25 fms. west of the West shaft, a strong, almost vertical, gossany lode was cut which ranges E. 30° N. and is composed of cavernous quartzose breccia. Almost below this point in the lower adit a strong vertical joint having the same strike was intersected; a considerable amount of water is discharged from it. There is no doubt that these fractures pertain to the District lode and there are probably others still farther west. The same lode was driven through in a cross-cut from the 35-fm. level near the Main shaft about 23 fms. south of the shaft. It had the same strike as at the west end of the mine, but yielded no ore. A few fathoms east of the fissure which crosses the lower adit the slaty rocks are traversed by numerous narrow joints, filled by thin strings and veins of blende free from galena. Ground of this nature was traversed for about 8 fms. and the adit then entered a considerable thickness of almost solid blende. It is probable that this blende-impregnated ground is a part of the District or Hafan lode, but up to the present its extent and strike have not been sufficiently explored.

Cross-courses.—In this mine several strong north-and-south faults have been crossed in the levels. A fault with an easterly dip of 53° crosses the top adit about 20 fms. west of the West shaft. What is apparently the same fault was met in the lower adit 26 fms. west of the main shaft, where it dips to the east at 40° . About 56 fms. west of that shaft is another fault dipping in the same direction at 50° , and at 15 fms. west of the shaft the adit is crossed by a fault dipping west at about

45°. These faults appear to shift the lodes in a manner which suggests that each is normal, but the amount of displacement is small.

Output.

There are returns of lead-ore for the years 1882, 1887, 1889, 1909-11, 1913-16.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.	Blende.
Tons. 1,240	Tons. 898	% 72·4	Oz. 6,361 ¹	Oz. 5·4	Oz. 7·5	Tons. 99

MYNYDDGORDDU.

(6-in. Sheet, Card. 4 S.W., Long. 3° 57' 40", Lat. 52° 27' 23".)

This is a small mine, situated about 1 mile west of Elerch or Bontgoch, and 4 miles by road from Bow Street station on the Cambrian Railway. It was started about 50 years ago on the finding of some large blocks of solid galena near the outcrop. Burnett's engine-shaft was sunk vertically to 46 fms. below a shallow adit (about 680 O.D.), which opens 100 yds. to the south-west. After cross-cutting to the lode, levels were opened at 12, 24, 34 and 46 fms. (Fig. 3). Near the shaft a cross-cut

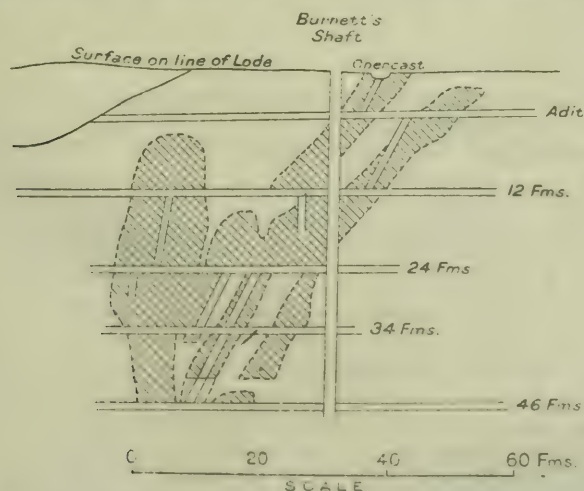


FIG. 3.—LONGITUDINAL SECTION OF MYNYDDGORDDU.

¹ The amount of silver in the whole of the ore may be estimated at 6,760 ozs.

was driven to the north-west from the 12-fm. level in order to prove the ground in that direction, but met nothing of value. A branch striking south-west was also tried for some distance in this level.

The rich ore discovered at the surface proved on further development to be a shoot inclining to the west at about 30° from the vertical, and of limited extent along the strike of the lode; its eastern boundary is sharply defined, the other less so. At the 12-, 24- and 34-fm. levels its average length is about 32 fms., but in the bottom level it is less than 20 fms.

Output.

From these restricted workings a considerable amount of galena and blende was obtained, the average yield of lead-ore being about 18 cwt. per square fathom. The highest return (1880) was 240 tons of galena and 40 tons of blende.

The mine was working from 1874-84, and the bunch is probably exhausted.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.	Blende.
Tons. 901½	Tons. 675¼	% 74·9	Oz. 9,725 ¹	Oz. 10·8	Oz. 14·4	Tons. 182¼

PENYCEFN OR COURT GRANGE.

(6-in. Sheet, Card. 6 N.W., Long. $3^\circ 58' 45''$, Lat. $52^\circ 27' 3''$.)

Penycefn or Court Grange mine is 2 miles east-north-east of Bow Street station and $3\frac{1}{2}$ miles distant by road. The lode underlies to the north at 75° to 80° and ranges east-north-east. It is 4 to 6 ft. wide with a clearly-marked footwall; towards the hanging-wall the rocks are fissured by numerous joints, all of which are somewhat mineralised. The material in the dumps consists of minutely-brecciated soft mudstones which belong to the highest horizon of the Frongoch formation, in which a productive lode has been worked west of the Plynlimon range.

¹ There is clearly an error in the return of silver for 1882; for 1,376 oz. are returned from 8 tons of lead-ore; moreover, there are no returns of silver for the year 1874-6 ($120\frac{1}{2}$ tons of lead-ore). Neglecting 1882, the average content is as shown above. The probable silver-content of the total lead-ore returned from the mine when these corrections are made agrees, as it happens, with the amount returned above.

It is said that a north lode producing lead-ore in blocks of a hundredweight each, was cut in making the foundations of a 40-ft. waterwheel, but no further trials appear to have been made on it.

At the east end of the Penycefn workings the lode splits into two branches; it does not seem to have produced much galena east of that point, but its outcrop can be traced by old trials for over half a mile across the Elerch road, and on to the common to the north. Four hundred yards east of the boundary of the common a cross-cut southward intersected a strong lode consisting of brecciated mudstones, and quartz bearing a considerable amount of blende in association with some galena, a large amount of cerussite and some pyromorphite; similar material is seen at the outcrop south of the cross-cuts.

It is not improbable that this north-dipping lode is related to the great south-dipping fracture of the Hafan lode which pursues a parallel course less than a quarter of a mile to the north, and there is some evidence of subsidiary fractures connecting the two. The productive part of the Penycefn lode is in fact continuous in direction with the Hafan lode between Cefngwyn and the Mynyddgorddu mine.

Unfortunately no record of the workings is available of later date than a longitudinal section dated 1846, preserved in the Home Office, but it is clear that the mine has been worked to a considerable extent since that time. In 1846 the engine-shaft was about 44 fms. below the surface, or 30 fms. below a shallow adit (about 430 O.D.), and another shaft, 60 fms. to the east, was 15 fms. below the adit. The ore-body, so far as it had been proved at that time, formed two parallel shoots dipping westward at an angle of about 30° from the vertical, and of a total length at the 15-fm. level of about 60 fms.

A. Francis (p. 17) states that the mine had been worked above the adit-level about 1800, and that about 1840 it was 30 fms. under the adit. Also that some time after 1850 it was sunk to about 60 fms. under the adit, but that the deepest levels had only been driven a short distance on the lode. The north lode discovered in cutting the wheel-pit had, according to him, not been tried at all.

Output.

Returns of lead-ore are given for the years 1845, 1846, 1850-53, 1855, 1862, 1864, 1866, 1869, 1878-82, 1888, 1890, 1891, but returns of silver are also made for the years 1854, 1856, and 1889; the lead-returns for those years were probably omitted in error. An estimate has been made of the probable amounts for those years (total, 82 tons of ore and about 60 tons of metal)

based on the average silver-content for a number of years, and is included in the figures given below :—

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 1,457	Tons. 1,059	% 73·0	Oz. 17,124 ¹	Oz. 27·6 ²	Oz. 37·8

Blende was returned in 1879, 1881–83, 1890, 1891. Total, 87 tons.

BRONFLOYD (a corruption of BRYN LLWYD).

(6-in. Sheet, Card. 6 N.E., Long. 3° 58' 15", Lat. 52° 25' 52".)

This mine is situated on the slope south of Nant Silo, 2½ miles E. by S. of Bow Street station and about 3 miles from it by road. It ranks with Goginan, Talybont, Daren, &c., as one of the oldest mines in the county and was certainly worked by Thomas Bushell about 1645; he had purchased it from Lady Middleton, to whom it had been granted, together with those mentioned above, by King James. It may be presumed, therefore, that it was one of the mines worked by Sir Hugh Middleton about 1600.

In view of their antiquity the extent of the workings is much less than might be expected. There are apparently three lodes, but the "north" and "middle" lodes only have proved productive hitherto. The south lode which has been exposed for a length of about 20 fms. in a shallow adit, is hard and brecciated, with much quartz and spots of galena. The middle lode was reached from No. 2 shaft, which stands by the side of the cart-track due south of the dressing-floors and has been sunk to a depth of 50 or 52 fms. Below this level a winze has been sunk to the 70-fm. level, which connects by means of a cross-cut with the corresponding level on the north lode, worked in the No. 3 shaft. In former times the mine was drained by an old adit (about 280 O.D.), which, commencing as a cross-cut 100 yds. east of the dressing-floors, was driven towards the No. 1 shaft, and thence mainly on the middle lode westward to the No. 2 shaft in which it lies about 30 fms. below the surface.

In order to obviate the expense of keeping such a long adit in repair and to facilitate the carriage of the stuff to the dressing-floors a new adit cross-cut (about 305 O.D.) was driven south

¹ For several years no silver is computed for this mine, which is one of the richest in that metal in the country. Assuming the average content given in the columns we arrive at the figure of about 40,000 oz. as a more probable estimate of the silver-content of the ore returned since 1845.

² This ratio was obtained from the returns for those years in which lead-ore and silver are both given. The silver per ton of ore varies between 20 and 45 oz. in different years.

from the mine-buildings. In No. 2 shaft it is about 5 fms. nearer the surface than the old adit.

From this shaft the 40- and 50- (or 52-) fm. levels have been driven on the lode for about 10-15 fms. east and west of the shaft. The 50-fm. level was then turned north-westward to cut the north lode; a cross-cut south for 12 fms. towards the south lode does not appear to have met anything of value.

From the 50-fm. level near the shaft a winze was sunk on a bunch of ore to a cross-cut south at the 70- (73-) fm. level from the north lode in No. 3 shaft. At this depth the two lodes are 28 to 30 fms. apart. Communication between the workings from No. 2 and No. 3 shaft is made also at the 50-fm. level, which was driven in country-rock for a distance of about 55 fms. to intersect a cross-cut south at the same level from No. 3 shaft. A cross-cut north (called Barton's) in the 52-fm. level, near the No. 2 shaft, cut the north lode at a distance of 25 to 28 fms., and Lewis' cross-cut south from No. 3 crossed the middle lode about 15 fms. south-west of No. 2. It appears from the plans that the middle lode has only been worked for a distance of 20 to 30 fms. near the No. 2 shaft, and the ground to the east, where a good deal of ore was stoped above the old adit has not been tried subsequently.

The No. 3 shaft meets the north lode at a depth of about 80 fms. below the surface and has been continued vertically to a depth of 100 or 104 fms.; levels at 52, 62, 73, 84, 96 and 104 fms. have been driven for 10 to 20 fms. east and west of the shaft. The ore has been taken out to the surface. A few years ago a run in the stope above the 50-fm. level completely obliterated the shaft below the 80-fm. level. The subsidence continued to the surface of the ground, forming a deep cavity in the sides of which the lode is exposed. A cross-cut (called Lloyd's) at the 52-fm. level was driven southward until it cut the middle lode near its hanging wall; the minimum distance between the lodes is there about 20 fms. At the 84-fm. level another cross-cut (called Balcombe's) also cut the middle lode in a distance of about 24 fms.

South and west of No. 3 considerable drivages westward on the 40- and 50-fm. levels are indicated on some of the plans, that on the 40-fm. extending to within about 45 fms. of the No. 4 shaft, which is sunk a few fathoms from the surface. Owing to the discordance between different plans the actual position and the relation of these extensions to the other workings is doubtful. The ore-body in each lode appears to be a shoot dipping westward at an angle of about 20° from the vertical and about 30 to 40 fms. in length, but there is evidence of another bunch which has been stoped away in parts above the old adit for a distance of 50 to 60 fms. west of the No. 1 shaft. Except near that shaft this ore has not been tried below the adit.

Considering the limited lateral extent of these bunches and the fact that the mine had been producing at intervals for 200 to

250 years prior to 1851, the subsequent output is larger than might be expected, and suggests that the average ore-content was fairly high. The stoped ground on both lodes may be estimated at about 4,000 sq. fms.; the output of lead-ore since 1851 is 6,400 tons; if account be taken of all the ore that has been got from the mine it is probable that the lodes yielded on an average over 2 tons per square fathom.

Output.

There are returns from this mine for the years 1851, 1852, 1855-72, 1874-84, 1886-88, 1891, 1892:—

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Metal.
Tons. 6,423	Tons. 4,714	% 73·4	Oz. 35,024 ¹	Oz. 7·0 ²	Oz. 9·45

Copper-ore, 23 $\frac{1}{4}$ tons, producing 2 $\frac{3}{4}$ tons of copper, were sold in 1865.

EAST DAREN OR CWMSYMLOG.

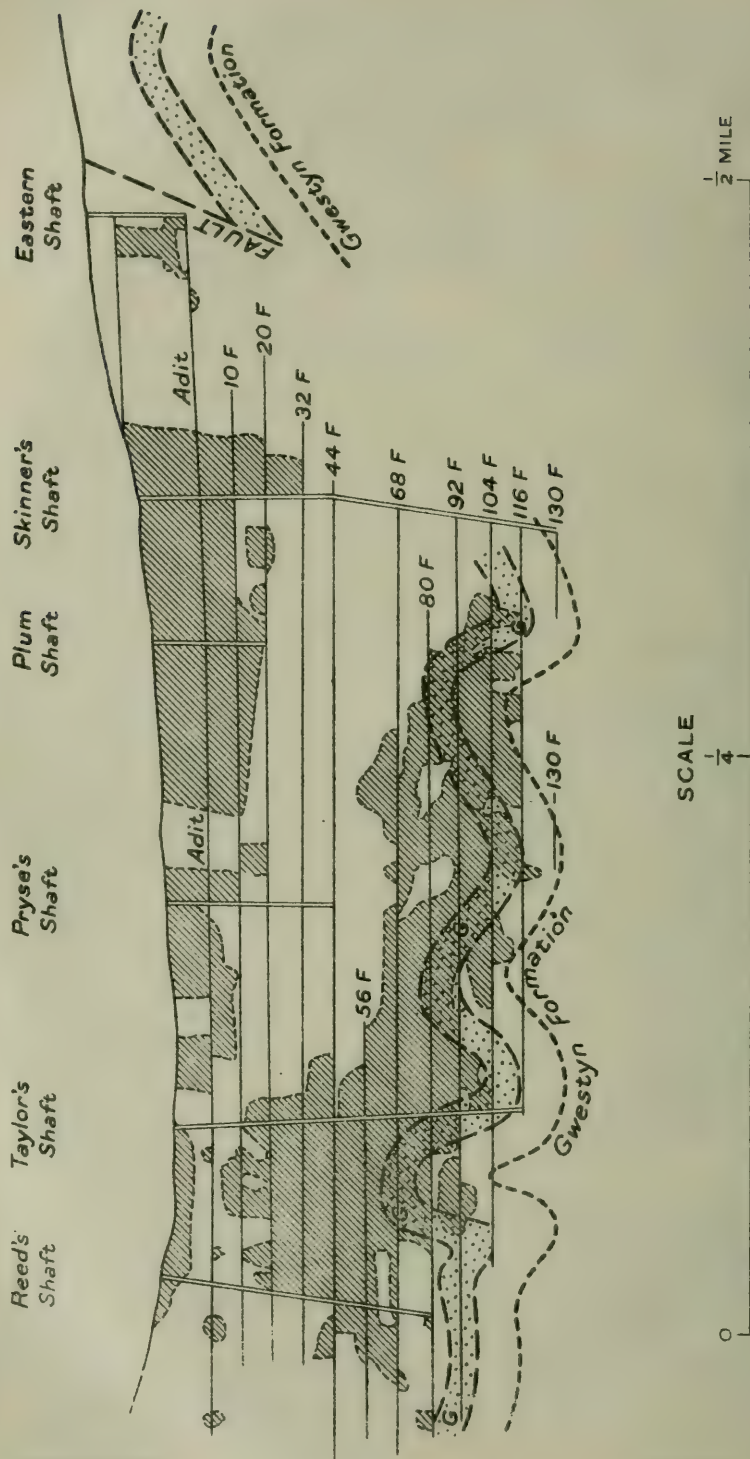
(6-in. Sheet, Card. 7 N.W., Long. 3° 54' 40", Lat. 52° 26' 5".)

This mine lies 4 $\frac{3}{4}$ miles east of Bow Street station and about 5 $\frac{1}{2}$ miles from it by road. It was worked intermittently for several centuries up to 1901 when the last parcel of ore was sold. The earliest record of it is contained in Sir John Pettus's *Fodinae Regales*, when it was worked by the Society of Mines Royal. Meyrick³ states that it was the profits from this mine "which enabled Sir Hugh Middleton to undertake the New River from Ware to London. From 1750 to 1770 it was constantly worked and produced pretty good profit, but after that it was discontinued till 1805, when Mr. Pryse of Gogerthan . . . took it in hand and found it succeed admirably." Sir Hugh Middleton is said to have made profits there of 2,000*l.* a month; he was succeeded by Mr. Bushell and after by Sir Humphrey Mackworth and the Company of Mine Adventurers (about 1700-1744). In 1700 Waller published a brief description and a plan from which it appears that the main work was being done at the eastern end of the mine near Blaencwm.

¹ There are serious omissions in the silver returns, and some obvious errors. In 1868, 500 oz. of silver are returned from 482 tons of lead-ore; as less than 3 oz. per ton are disregarded in the returns the amount of silver is probably an error. Although the silver-content ranges between 3 and 15 oz. per ton, there is no reason to suppose that it was negligible in any year. The total silver may, therefore, be estimated at about 44,750 oz.

² These values are the average of those years, omitting 1868, for which returns of silver are given.

³ "History of Cardiganshire," p. ccxxxv.



LONGITUDINAL SECTION OF EAST DAREN.

When Messrs. Taylor & Sons took over the mine in 1847 the old workings extended in places at the eastern end to a depth of over 40 fms. below the adit, or about 60 fms. below the surface. They had become poor in depth and had been abandoned for that reason.

Messrs. Taylor commenced operations by sinking Reed's shaft near the western end and explored the lode in its neighbourhood; the earlier years proved so disappointing that they almost relinquished the mine as a failure. Subsequently, on meeting with better success, four principal and two subsidiary shafts were sunk or deepened, viz.:—Reed's (80 fms.), Taylor's (116), Pryse's or Loveden's (44), Plum (20), Skinner's (130), and the eastern shaft (adit); these were sunk mainly or wholly on the lode.

The shallow workings are drained by an adit (about 710 O.D.), driven in from the brook N.N.E. of the western or Reed's shaft. Levels were extended at 10, 20, 32, 44, 56, 68, 80, 92, 104, 116 and 130 fms. below the adit.

The form of the ore-body disclosed by the workings presents some points of interest (Pl. XI.). Between Reed's and Taylor's shaft the lode yielded from 1 to 5 tons per fathom in driving and stoping (the average being about $1\frac{3}{4}$ tons) in most of the levels down to 80 fms.; below that there was a fairly rapid falling-off down to 116 fms., where the lode was almost barren.

Between Taylor's and Skinner's shafts the ore formed two distinct layers gently inclined to the east and separated in places by a depth of 50 to 60 fms. of barren ground; the upper layer, the bottom of which lay from 10 to 30 fms. below the adit, was exhausted by the old miners (Fig. 14). Messrs. Taylor made extensive trials of the lode between the 20- and 68-fm. levels, but it proved to be barren almost down to the latter level; below this a highly productive layer of ore extended downwards to the 116-fm. level. The top and base of this layer are, approximately, parallel to one another and to the bottom of the older workings above.

Throughout most of this mass the values ranged from 1 to 2 tons per fathom of driving and stoping; the 116-fm. level carried from $\frac{1}{2}$ to $1\frac{1}{2}$ tons per fathom for a length of nearly 140 fms., but the bottom or 130-fm. level proved all but barren, except in the neighbourhood of Skinner's shaft. The lower ore-body was, therefore, sharply limited in depth, as appears also to have been the case with the upper ore-body. Whereas, however, the earliest workings appear to have been in the neighbourhood of the eastern shaft, later operations centred mainly about a point 120 fms. farther west, while the richest part of the workings under Messrs. Taylor's management lay about 200 fms. farther west again.

Although the earlier workings became unproductive in depth and were abandoned, yet underneath the old bottoms an ore-body of considerable size was subsequently worked, the existence of which would not have been suspected but for its occurrence

at one point near the surface farther west. The form of these ore-bodies suggests a possible relation to the nature and inclination of the country-rocks adjoining the lode. The information contained in Messrs. Taylor's annual reports and the surface exposures appear to lend support to this suggestion.

Reed's shaft stands, approximately, on the axis of a well-marked anticline which can be traced southward past the western end of Cwmerfin and Goginan mines; those mines and East Daren all lie, therefore, on the eastern flank of the same fold. About 100 yds. east of the eastern shaft or half a mile east of Reed's shaft there is another important anticline; the rocks between these must, therefore, form a basin or syncline, though as usual in the district there are in addition to the major folds several minor undulations.

The strata at the surface in the core of the eastern anticline consist in the main of pale-greenish compact mudstones about 350 ft. above the base of the Frongoch formation; in the western fold these rocks lie somewhat deeper. About 250 ft. above the base there is a band, 50 ft. thick, of rusty-weathering shales similar in character to the underlying Gwestyn rocks, and only distinguishable by their fossils. There is also a band of calcareous grits, which lies about 120 ft. above the base.

From Messrs. Taylor's reports, it appears that in sinking Taylor's shaft these grits ("porphyry") were met between the 80- and 92-fm. levels, and exercised an unfavourable influence upon the lode while at the 104-fm. level beds of hard grit were cut through west of the shaft. Hard beds were also encountered in the 68-fm. level midway between Reed's and Taylor's shafts and at various other points, both on the north and on the south lode (*see* Pl. XI.). Their position in the mine agrees with the structure indicated by surface-exposures.

As these beds lie at a constant distance above the underlying Gwestyn shales, the figure shows that that formation must have been nearly or actually touched in the bottom workings of the mine, and it is clear that the bottom of the ore-body as far as Skinner's shaft, if not farther east, bears a close relation to the base of the Frongoch formation. This raises the possibility that the falling-off in the yield at a depth may have been caused by the presence of those shales. It is unfortunate, however, that the nature of the rocks met with in different parts of the mine was rarely recorded in sufficient detail to afford as precise information as could be desired. The rock at the 116-fm. level in Taylor's shaft is described as "light clay slate" (Frongoch formation), but among the debris from Skinner's shaft the Gwestyn rocks can be recognised.

The East Daren lode strikes west-south-west, but the plan shows that it undulates considerably in its course across the mine; at the same time its dip changes from point to point and from level to level. At Pryse's shaft its average inclination is about

56°, but between Taylor's and Reed's it rises to 72° and in the lower levels it is almost vertical.

Throughout much of the mine it consists of two parts or branches, each about 6 ft. wide, and at a varying distance apart; the opencast workings north of Skinner's shaft indicates a total width of 40 to 50 ft.

From a point east of Taylor's shaft the two branches diverge at a considerable angle westward; the north branch, supposed to be the main lode, was followed in the adit for about 43 fms. west of Reed's shaft. Its line of bearing, if continued, would carry it towards the old mine called Gwaithyrafon, which is by the side of the stream, half a mile below East Daren.

The southern branch or "south lode" was worked from the 56- to the 104-fm. levels and for a distance of about 160 fms. east of Taylor's shaft; it yielded in places up to $1\frac{1}{2}$ tons per fm., though it was not so productive as the main lode in the same levels. Near Taylor's shaft the south lode strikes W. 35° S. and is separated from the north lode by a distance of 30 to 40 fms. It ranges directly for Cwmsebon or South Daren mine, which is about three-quarters of a mile distant, but extensive "costean" pits on the surface west of Reed's shaft do not appear to have met anything of value. There is little doubt that in splitting westward into two or more branches, the East Daren lode becomes weakened or impoverished.

Numerous trials for the eastward continuation of the lode were made by Messrs. Taylor. A cross-cut north from the north side of the reservoir met with no success, while another, called the eastern cross-cut was made about 90 fms. to the east. The base of the Frongoch formation is, however, displaced by the lode on the hillside 40 to 50 fms. north of the mouth of the cross-cut; it is probable, therefore, that the so-called "counter lode," met at about 30 fms., is really the main lode, but in an unproductive and attenuated form. Messrs. Taylor believed that it was the Cwmerfin lode, but this must be some distance farther south.

Nothing is known of it beyond this point, and it is doubtful if it continues far. Some years ago a trial at considerable expense was made at Nantymoch, 5 miles to the north-east to prove the supposed intersection of this lode with a cross-course, which was said to traverse the country for miles in a south-easterly direction, and for which there is not the slightest evidence or probability.

Output.

Returns of output are available for the years 1852-93, 1895-97, 1899-1901. From 1852 to 1883 the official figures can be compared with the sales of ore recorded in Messrs. Taylor's annual reports. Between 1852 and 1860, Messrs. Taylor sold lead-ore at the rate of 21 cwt. to the ton: an attempt has been made

in the Mineral Statistics for certain years to correct to the 20-cwt. standard, but it appears to have been overlooked occasionally; moreover the correction was applied in the Mineral Statistics, for 1861-3, when it was no longer necessary. Messrs. Taylor's figures, which appear in their annual balance-sheets, are here accepted in lieu of those in the Mineral Statistics; the amount of available lead has been recalculated for the revised figures the same ratios being used as in the official returns.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons.	Tons.	%	Oz.	Oz.	Oz.
24,460	18,334	74·9	415,850	17·0	22·7

According to Meyrick (p. ccxxxiv) the ore in the older workings yielded about 40 oz. of silver to the ton of lead; and as 13 cwt. of lead were obtained from a ton of ore, this corresponds to 26 oz. per ton of ore.

Smyth (p. 641) suggests that it was probably ore from this mine that yielded as much as 100 oz. per ton of lead. Messrs. Taylor state that the ore in their earlier workings contained from 35 to 40 oz. to the ton, but the later yield fell below this figure.

In order to see whether there is any evidence for a change with increasing depth the silver-content has been calculated for groups of years with the following results:—

—	Silver per ton of Ore.	Silver per ton of Lead.
	Oz.	Oz.
1852-9 - - - - -	14·5	19·5
1860-9 - - - - -	16·6	22·3
1870-9 - - - - -	20·3	27·
1880-9 ¹ - - - - -	17·1	20·7
1890-1901 - - - - -	18·7	24·9

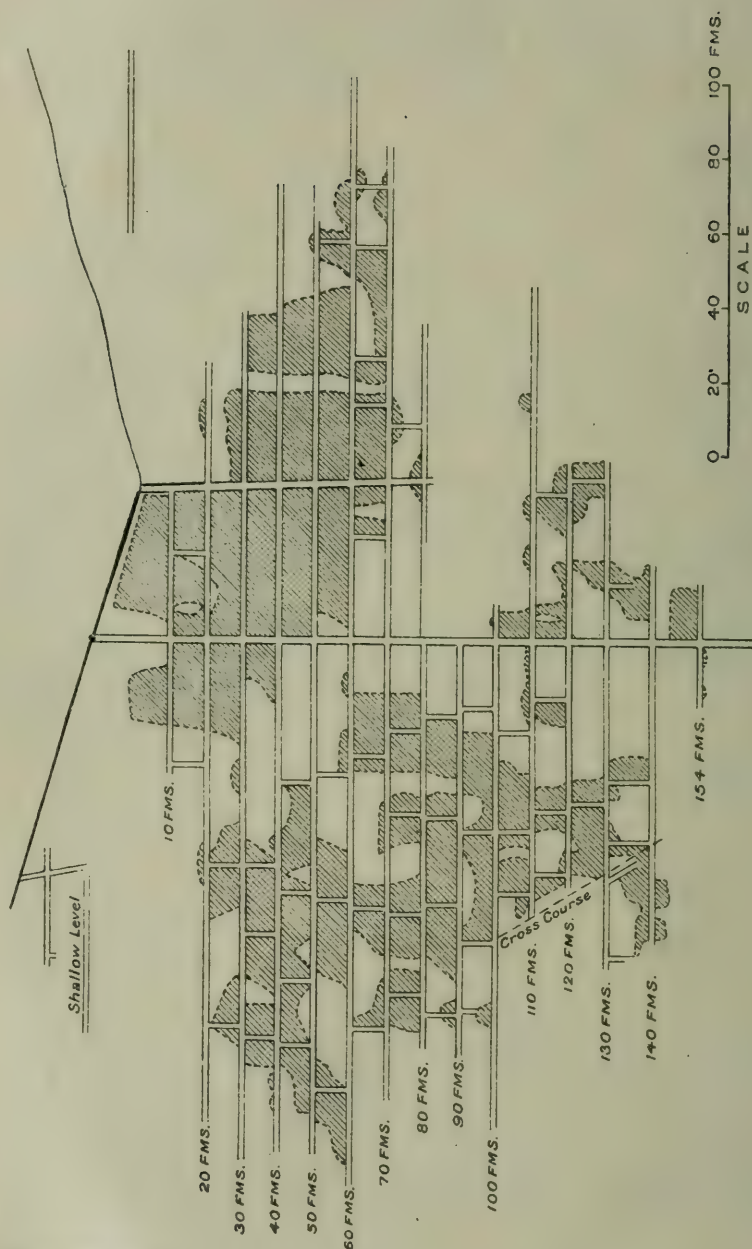
On the whole these figures do not support the view that the silver-content was higher in the shallower parts of the mine, though if the halvans were derived from early operations they may indicate a slightly higher content. On the other hand the oldest workings under Middleton, Bushell, and others, were confined to the upper ore-body which might have had a higher silver-value.

¹ From 1876-79 217 tons of lead-ore obtained from crushing old halvans or waste-heaps yielded 5,380 oz. of silver or 24·8 oz. per ton of ore. This has been excluded from the figures for this group of years.

W.

36471/33/822.1000, 3/21.

E.



LONGITUDINAL SECTION OF SOUTH DAREN.

C & R. L. 100. 361.

SOUTH DAREN OR CWMSEBON.

(6-in. Sheet, Card. 7 N.W., Long. $3^{\circ} 56' 2''$, Lat. $52^{\circ} 25' 45''$.)

South Daren is situated in the Erfin valley half a mile above Penbonthrhydybeddau, and about 5 miles by road from Bow Street station.

It is the deepest mine in the whole area, and has been developed almost entirely since 1840, when a course of very rich ore was discovered in sinking the old engine-shaft to the 20-fm. level from the surface (about 505 O.D.). This shaft was subsequently deepened to 80 fms., and later a new shaft was sunk on higher ground, 80 yds. to the south-west to the 154-fm. level,¹ that is, to a total depth from the surface of 166 fms.; the bottom of the mine is thus 70 fms. below Ordnance Datum. Levels were driven regularly at 10-fm. intervals down to 140 fms.; but the bottom lift is 14 fms. (Pl. XII.).

In the western shaft the lode dips to the south at an average inclination of 80° , but in the lower half of the shaft it is almost vertical; the dip diminishes somewhat westward and increases in the opposite direction. The lode is from 3 to 12 ft. wide and carries galena rich in silver, associated with a considerable proportion of copper-pyrite and some blende; it is visible in a shallow adit on the hillside west of the shaft, where it dips to the south at 70° . The country-rocks at the surface consist of the pale-greenish mudstones which are characteristic of the lower part of the Frongoch formation; near the western shaft the debris from the workings include rusty shales derived apparently from the 50-ft. band, which was described in connection with East Daren. The strata dip generally eastward, and lie on the flank of an anticline which passes through the western end of the mine.

It is not possible to estimate with any accuracy the depth to the Gwestyn formation in this locality; the thickness of the group of pale-green mudstones in which Cwmerfin, East Daren, South Daren and Great Daren mainly lie may be greater than in districts farther east, having regard to the large extent of the country they occupy between South Daren and Great Daren. It is almost certain, however, in view of the great depth of the mine, that the Gwestyn shales were entered.

The ore was found in two distinct bodies, each dipping to the east at an angle of about 30° from the vertical. A. Francis² records that at the 20-fm. level it ranged in value from 12*l.* to 60*l.* per fm. At the prices then ruling this would correspond to a yield of one to five tons. The managers of the mine reported to the directors in 1869 that the lode in the stopes above the 40-, 50- and 60-fm. levels was 2 to 3 ft. wide and worth from 10*l.* to 12*l.* per fm. for lead and copper (12 to 13 cwt. per fm.)

¹ As the old engine-shaft is situated in the bottom of the valley the levels are reckoned from the top of that shaft.

² History of Cardiganshire Mines, p. 44.

and in the 70-fm. level from 12l. to 20l. (13 cwt. to 1 ton per fm). Somewhat higher values are recorded in the following year, especially above the 60-fm. level. The average throughout the mine is about $15\frac{1}{2}$ cwt. of galena per fathom and 2 cwt. of copper-ore including some blende. The eastern ore-body was explored from the surface to the 80-fm. level, but was not productive below the 70-fm.; its average length was about 85 fms. The 110-fm. level was driven underneath it, but without success. The western bunch was worked to the bottom of the mine, but was less continuous than the eastern body; its average length was about 100 fms., of which about 60 to 70 fms. were stoped away in each level; the actual length of the stopes in the 140-fm. level is about 50 fms.

The bottom or 154-fm. level was only driven 12 to 14 fms. east and west of the shaft; ore was found throughout its length, and it seems probable that it continues below that level. Old miners say that spite of its depth the mine was comparatively dry; if it is considered desirable to do so it will not be a difficult matter, provided surface water is excluded, to unwater the workings and to carry the shafts to a still greater depth.

Output.

Since 1845 there are returns from this mine for the years 1845-51, 1857-93¹ :—

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 9,248	Tons. 6,869	% 74·3	Oz. 173,527 ²	Oz. 27·4	Oz. 36·1

Blende was returned in 1872 (175 tons), and 1878 (21 tons); total, 196 tons.

Copper-ore was returned in the years 1844-47, 1849, 1860, 1864, 1865, 1882-93. Total, 1,048 tons; average yield, 9·4 per cent.

¹ In 1864 there is a return of 106 tons from "Daren South," and 122 tons from "Cwm Sebon or South Daren." The first figure has been adopted, though it is possible that two returns were made in that year. The returns for 1863 and 1865 are 68 and 327 tons respectively.

² Silver is omitted from the returns for a considerable number of the earlier years, and in view of the uniform yield of later years the above figure is undoubtedly much too low. A more probable value is 241,300 oz.

The silver-values for the groups of years are:—

	Silver per ton of Ore.	Silver per ton of Lead.
1845-9 - - - - -	Not known	Not known
1850-9 - - - - -	25·7	31·8
1860-9 - - - - -	26·0	34·3
1870-9 - - - - -	27·2	35·3
1880-9 - - - - -	27·7	36·7
1890-3 - - - - -	29·8	39·2

These values are fairly constant and the slight increase is probably without significance. There is, therefore, no reason to believe that the ore nearer the surface had a higher content of silver than that from the deepest levels.

DAREN, GREAT DAREN OR OLD DAREN.

(6-in. Sheet, Card. 7 N.W., Long. 3° 56' 53", Lat. 52° 25' 35".)

The main shaft is near Daren farm; the adits are from 600 to 800 yds. to the north-east, on the outcrop of the lode.

The mine lies to the south of Penbontrhydybeddau and half a mile west of South Daren. At one time it was one of the most celebrated mines in Cardiganshire and has undoubtedly been worked for a very long period. It was referred to by Sir John Pettus as a "Roman work." There is no direct evidence to connect the Romans with any of the mines of this district, but the use of the expression indicates that there were workings of considerable antiquity in existence when the Society of Mines Royal took over the mine under a patent granted in 1568. Adjoining the outcrop of the lode is an oval hill-camp of the type commonly known as British, but the age of which can only be conjectured; along the outcrop of the lode there is a deep and wide trench, which encroaches upon the defences of the camp in such a way as to suggest that it is in the main of later date. This excavation is about 600 yds. in length, 20 to 30 yds. wide, and is still 10 to 20 yds. deep in many places. An enormous amount of material must have been removed from it. Unfortunately, little is known of the underground workings.

Meyrick (1810) records (p. ccxxxv) that the mine was in its prime from 1720 to 1740, but had not been worked since 1798. From a statement made by A. Francis (pp. 39-41), it appears that it was taken up anew about 1825, after which it continued to work intermittently until 1879. It is clear, however, that the output since 1845 gives but little indication of the riches that had been obtained in earlier years.

The mine was worked mainly from adits driven in from the north side of the hill, or by a large number of shafts which were sunk near Daren farm at intervals of 20 to 50 fms.; in this

respect the method of working compares with that at Esgairhir. According to a longitudinal section dated 1911, preserved in the Gogerddan Estate Office, the adits are the upper level (about 776 O.D.), Level y Coed (about 570 O.D.); Francis's level (about 520 O.D.) and the bottom or Oliver's level near Cwm-daren stream (about 426 O.D.). A shaft near the mouth of Level y Coed has been sunk below the bottom adit. A longitudinal section dating from about 1842 or 1844, preserved in the Home Office, shows a number of shafts to the following depths: Old Engine-shaft, about 5 fms. below a 12-fm. level; shaft 31 fms. farther west, to the 12-fm. level and another to the same depth, 32 fms. to the east; these appear to be very old workings. Also the Engine-shaft, 61 fms. east of the Old Engine-shaft, sunk to 50 fms. from surface (actually 54) with levels at 10 (11), 20 (24), 30 (34), 40 (44) and 50 (54) fms.; two shafts at 20 and 45 fms. to the east, also to the 50-fm. level, and two other shafts at a distance of 95 and 217 fms., to a depth corresponding to about the 10-fm. level of the Engine-shaft. These shafts are drained to about the 15-fm. level by an adit which seems to correspond with Level y Coed. The 12-fm. in the Old Engine-shaft is equivalent to the 20-fm. in the New Engine-shaft.

Later workings were carried out mainly from Francis's level from which the ore was trammed to the dressing-floors about three-quarters of a mile down the valley; according to the newer section referred to above, the "main shaft," which is about 50 fms. west of the "pumping-shaft" is supposed to be sunk to 70 fms. below the surface. The identification of these shafts at present is not certain. The "pumping-shaft" appears to be the Old Engine-shaft of the earlier section; the main shaft is of more recent date, and would appear to be that which was sunk according to A. Francis near the supposed point of junction of the Daren and South Daren lodes. The length of Oliver's adit is unknown.

It is probably safe to assume that the ore has been taken away generally to the lowest drainage-level, and in places to a depth of about 25 fms. below it, or to about 270 O.D. In comparison with the adjoining mine of South Daren, which commences at about 500 ft. above sea-level, Daren must be regarded as a shallow mine and the lowest workings are nearly 700 ft. higher than those of South Daren. There is reason to believe, however, that the lode proved less productive at the deeper levels than nearer the surface and the attempt to exploit the junction of the Daren and South Daren lodes near Daren farm did not meet with the success which was anticipated.

The Daren lode ranges N.E.-S.W., and dips to the north-west at 60° to 70°; the country-rocks are mainly pale-green mudstones which occur near the lower part of the Frongoch formation; in this district they cover a larger area than to the east and may therefore be of greater thickness. Near

Daren camp the lode is of great width and yielded galena in association with some copper-pyrite. According to their strikes, the lodes of Daren and South Daren should intersect near Daren farm, but owing to the fact that they dip in opposite directions their junction is not of such a favourable character as it would be if both had the same inclination, in which case the two lodes would probably run in company for some distance and this might lead to local enrichment.

At Cwmdaren, opposite the mouth of Oliver's adit, another adit, called Level Gopor (or the Copper Level), has been driven north-east on the Daren lode to the Cwmdaren or Copper shaft, which is 70 fms. from the level mouth, and is sunk to a depth of about 50 fms. below the adit.

The same lode or a branch from it has been worked in the Cerigyrwyn mine, 300 yds. to the north-east, where an adit called the Roman adit has been driven on the lode, and a shaft and winze sunk to an unknown depth below it; this appears to be an old working.

Less than half a mile to the north-east is another small mine called Gwaithyrafon (or the River-work), which is probably on the continuation of the same lode. There is reason to believe that the north or main lode of East Daren also passes through this mine.

Output.

Returns of lead-ore from Daren were made in the years 1849-60, 1862-66, 1870-79:—

Lead-ore.	Lead.	Ratio.	Silver	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 1,657 $\frac{3}{4}$	Tons. 1,234 $\frac{1}{2}$	% 74·5	Oz. 21,149 ¹	Oz. 21·8	Oz. 28·8

Copper-ore was returned in 1855-57; total, 51 $\frac{3}{4}$ tons. It is likely that some copper-ore was sold of which there is no record.

CWMERFIN.

(6-in. Sheet, Card. 7 N.W., Long. 3° 55' 5", Lat. 52° 25' 40".)

Cwmerfin lies in the Erfin valley, north of Goginan and about 5 $\frac{1}{2}$ miles by road from Bow Street station. A mine of this name is mentioned by Pettus as one of the Mines Royal

¹ The returns of silver for 1864, 1873 and 1874 are at the rate of less than 4 oz. to the ton, whereas in all other years it ranges from 20 to 25 oz.; in calculating the silver values given above those years have been omitted. The total amount of silver equivalent to the output of the mine since 1845 may be estimated at 36,000 oz. Meyrick states that a ton of lead yielded 35 oz. of silver, and a ton of ore gave 12 $\frac{1}{2}$ cwt. of lead (silver per ton of ore is, therefore, 21·9 oz.).

worked by that Society, but from the map and brief description given by Waller it is evident that the same name was applied to another mine about half a mile to the south-east, which was known at one time as Bwlch Cwmerfin and later Bwlch. Waller's map and the plan of the mine shows that the lode was entered by an adit driven from north to south, and not far to the south he indicates another lode, which it was intended to reach by a cross-cut, as one of the Goginan lodes. On the other hand, the Cwmerfin lode lies mainly on the north slope of the valley; further, it is at least half a mile distant from the Goginan lodes, which, therefore, could not be reached by a cross-cut of reasonable length.

There is no direct evidence that the mine is of such high antiquity as some others in the neighbourhood. According to Meyrick (p. cccxxvi) it had been idle since about 1795, but between 1848 and 1850 it was taken up by Messrs. Taylor & Sons, who sank two pre-existing shafts, the western or Engine-shaft and the eastern, Whim- or Drawing-shaft, to the 69-fm. level and also extended the adit which discharges near the bridge over the stream (about 595 O.D. (Pl. XIII.) Subsequently, two other adits were driven into the lode east of the Drawing-shaft. Williams's level (about 790 O.D.) is about 30 fms. above the adit, and Pryse's level (about 940 O.D.) is about 25 fms. higher. On the south side of the stream Taylor's shaft was sunk to the 45-fm. level, and 280 yds. farther west a trial was made by a shallow adit (about 660 O.D.), driven westward for about 42 fms. When Messrs. Taylor commenced operations, old workings had been carried down to the adit for about 80 fms. east of the Drawing-shaft, and to about 15 fms. below the adit near the Engine-shaft.

The lode in this part of the mine contained relatively short bunches of ore carrying from $\frac{1}{2}$ a ton to $1\frac{3}{4}$ tons per fathom, with considerable lengths of poor or barren ground. The bunches proved unreliable from level to level; for instance, a bunch 20 fms. in length was passed through in the 57-fm. level, but only held for about 3 fms. above the level and deteriorated rapidly downward. It was in the workings east of the Drawing-shaft and on a south branch of the lode, that the best ore was obtained. In the adit, 10- and 20-fm. levels, the lode yielded from $\frac{1}{2}$ a ton to 2 tons per fathom for 100 to 120 fms., but in the 32- and 45-fm. levels the bunches were short and unreliable. It is evident from the sections that the top of the ore-body sloped at a low angle eastward. Pryse's level was wholly barren, in Williams's level the ore gave out in about 50 fms., *i.e.*, about 25 fms. short of the mouth of Pryse's level; in the adit and 20-fm. level it extended about 100 fms. farther east.

It was likewise limited somewhat closely in depth, its base forming a shallow trough from the bottom of Taylor's shaft at the 45-fm. level to about 60 fms. between the Engine- and



LONGITUDINAL SECTION OF CWMERFIN.

the Drawing-shaft, and rising gradually thence to the 20-fm. level. The 69-fm. level, which was driven for over 100 fms. east of the Drawing-shaft, proved all but barren and in sinking the engine-shaft below that level no ore was found. East of the mouth of Williams's adit the lode was disturbed by two or more cross-courses which, as a rule heaved the lode for about 5 fms. to the north on the west side, thus indicating a downthrow to the west. The south branch was found at 10 to 13 fms. south of the main lode and diverged eastward at a small angle.

There is evidence at the surface of north-and-south faults or "cross-courses." One is visible by the footbridge over the stream south of New Inn, ranging N. 10° E., or, approximately, towards Pryse's level; this is probably the one met a little farther west in all the upper levels; another north-and-south fault, which has been mapped near Blaen Cwmsymlog, lies about 125 fms. to the east. This, probably, fades to the west at a considerable angle and may have been one of those met in the eastern levels.

Whether the form of the base of the ore-body bears any relation to the structure of the surrounding rocks is not proved, but it is suggestive that a well-marked anticline crosses the valley about 50 fms. west of Taylor's shaft, and that to the east of it the rocks descend into a trough and rise, with many undulations, to another strong anticline about a mile east of the mine. The rocks are, therefore, folded into a basin in form not unlike that of the base of the ore-body, which, in fact, must almost coincide for a considerable distance with the 50 ft. band of rusty shales that occurs about 250 ft. above the base of the Frongoch formation. The possibility must be borne in mind that the ore at Cwmerfin may correspond to the upper layer only of East Daren, which had in places a depth of 70 fms. as compared with a maximum of 90 fms. at Cwmerfin. It is not impossible, therefore, that the lode may be productive again in the blue and greenish strata underlying the shale-band. To test this would involve an expenditure which, in view of the "bunchy" nature of the Cwmerfin lode, would be hardly justifiable. Eastward the lode has not been traced; it ranges for the extensive peat-covered valley occupied by the Gwestyn formation east of Cwmsymlog. As already mentioned (p. 67), the lode believed to be that of Cwmerfin by Messrs. Taylor, is certainly the eastward continuation of the East Daren lode.

An attempt was made in the Melindwr valley or Ty'nypwll mine (see p. 145) to prove its continuation westward into the Goginan valley. An adit cross-cut, driven northwards into the side of the hill for 80 fms., cut a lode at about 15 fms. from the mouth and another at 80 fms. which was followed for about 200 fms. The latter, unlike the Cwmerfin lode, underlies to the north and a shaft was sunk to a 50-fm. level below the adit; some ore was found above the adit and in some of the levels, but not enough to make the venture profitable. Another adit

cross-cut was driven in a north-north-westerly direction for about 260 fms. with the intention of proving the Daren and South Daren lodes near their junction, but no lode was met in it.

This makes it probable that the lode near the mouth of the cross-cut represents the Cwmerfin lode; the north lode does not appear to have been met elsewhere.

Output.

Lead-ore is returned from Cwmerfin for the years 1849-1877 :—

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons	Tons.	%	Oz.	Oz.	Oz.
9,919 $\frac{1}{4}$	7,240	73·0	182,594 ²	19·9 ¹	26·9 ¹

Blende.—Returns of blende are given in Mineral Statistics for 1863, 1887 and 1889. Total, 36 tons.

According to Messrs. Taylor's reports, 7 $\frac{1}{4}$ tons were sold in 1857, but there is no record of the sale of blende in 1863, nor of lead-ore in the Mineral Statistics in the years 1887 and 1889.

Copper-ore.—Messrs. Taylor's reports record the sale of copper-ore in 1851, 1855, 1859 and 1871. Total, 60 $\frac{1}{4}$ tons.

GOGINAN.

(6-in. Sheet, Card. 7 S.W., Long. 3° 55' 40", Lat. 52° 25' 2".)

Goginan mine is situated on the north side of the Melindwr valley, about half a mile north of the main road from Llanidloes to Aberystwyth, and about 7 $\frac{1}{2}$ miles by road from the latter place. It was one of the mines worked by the Society of Mines Royal, and about 1699 Waller published a section indicating the work then in progress. From this it appears that an adit was being driven which would unwater the workings to a depth of about 50 fms. below the surface.

Reference is made to a pre-existing adit at a higher level, and to older workings which had been carried down to about 20 or 30 fms. below the surface. From later accounts by Messrs. Taylor, the lower adit appears to correspond with what is known locally as the Roman level, "from its having been driven in former times, and cut out entirely with chisels (as we are told was the practice of the Romans)"; the still older adit was in all probability the 26-fm. level.

At some later period a new adit was driven in at the lowest level obtainable; its mouth is near the bridge over the stream

¹ Meyrick states that the silver-content was 35 oz. to the ton of lead, or about 21·9 to the ton of ore.

² The probable amount of silver contained in the ore from the mine is 196,000 oz.

and at a level of about 260 O.D., and it became known as the deep adit or 60-fm. level. When Messrs. Taylor took over the mine about 1836, the lode had been worked down to the 60-fm. level for a length of about 100 fms., and in places a few fms. below. According to Meyrick the mine in 1810 had been idle for about 10 years.

Under Messrs. Taylor's management, the mine was worked mainly from three shafts in the following order from west to east, the depth of each being referred to the surface at Taylor's shaft :—Francis's shaft, 130 fms.; Taylor's shaft, 142 fms.; Gilbertson's shaft 100 fms. The adit or 60-fm. level was driven eastward and an incline at an angle of about 28° was made from the surface in the western part of the mine to the 120-fm. level between Francis's and Taylor's shaft. The levels in the mine are :—10, 16, 26, 40 (or Roman level), 50, 60 (or deep adit), 70, 80, 90, 100, 110, 120, 130 and 142 fms.

At a later period a shaft called the Western Engine-shaft was sunk at the west end of the mine to a depth of about 40 fms. under the adit for the purpose of testing the continuation of the lode in that direction.

East of Goginan there was an old mine called Brynpica which had been worked to a small depth from a shaft and a shallow adit, of which a section is given by Waller. Between 1850 and 1855 Messrs. Taylor extended the Goginan adit under the old workings and, subsequently, the 100-fm. level was driven through. The Brynpica shaft was then deepened to the 130-fm. level and a new shaft called the Western shaft was carried down on the lode from the adit to the 130-fm. level.

Still farther east lies the Bwlch (or Bwlch Cwmerfin) mine, which, at that time, was working ore up to the Goginan-Brynpica boundary. Messrs. Taylor sank a shaft close to the boundary with the object of proving the ore within their property; this was known as the Boundary shaft. The relation of these workings to one another and to the other workings farther east, is discussed below. It is clear from the plans and sections that three distinct ore-bodies were worked, viz., Goginan, Brynpica and Bwlch, of which the Goginan body was far the largest.

About midway between Francis's shaft and the Western shaft at Brynpica the ore-body proved unprofitable in all the levels down to 120-fms. and but little ore was obtained in the somewhat limited trials carried out from the latter shaft. East of Gilbertson's shaft all the levels eastward entered unfavourable, if not barren ground, and both in plan and section the workings end in an almost straight line; this was attributed to a "channel of soft ground."

As regards the deeper parts of the mine there appears to be no question that the richest deposits were about and above the adit or 60-fm. level, but they were still productive down to the 120-fm. level. Below that depth there was a rapid falling-

off and the 130-fm. level, both in Francis's and Taylor's shaft was poor. Taylor's shaft was finally sunk to about 142 fms., but the bottom level proved so barren that it was only driven a short distance. The lode at this point must be under the influence of the unfavourable ground met with in the upper levels, so that it was probably not the best point to select for the purpose of proving the mine in depth.

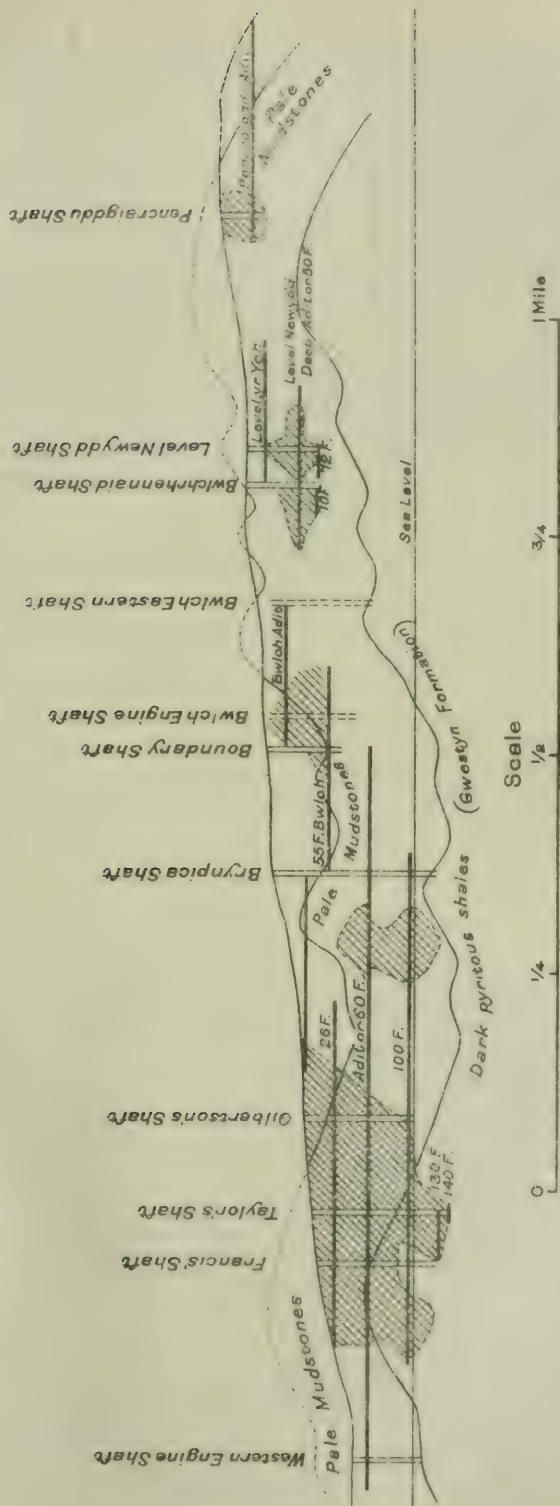
The lode is composed of brecciated fragments of blue and greenish mudstones, cemented and hardened by crystallized quartz, and carrying strings, ribs and bunches of lead-ore. It averaged 18 to 20 ft. in width and in places was extraordinarily rich.

With the exception of a few small bunches of lead-ore mixed with copper-ore found in driving the 100-fm. level about 40 fms. east of Gilbertson's shaft, the ground between Goginan and Brynpica proved barren. The Brynpica ore-body was about 100 fms. long and held down to about the 110-fm. level, below which it deteriorated rapidly and proved unproductive in the 130-fm. level. The Bwlch ore-body extended only a few fathoms within the Goginan-Brynpica boundary; the main part of it lay outside.

The Goginan ore-body lies on the eastern flank of the anticline that ranges through the west end of Cwmerfin and East Daren mines, and on the whole the country-rocks in all these mines are similar. The Gwestyn formation was probably entered in the western end of the ore-body, but owing to the possibility of an increase in the thickness westward of the group of pale mudstones which forms the lower part of the Frongoch formation, the exact depth of those shales is unknown. Capt. W. H. Paull informed me that certain rusty shales containing a few graptolites of the Gwestyn formation, which lie on the dumps near the Western Engine-shaft, were derived from about the 80-fm. level. This agrees with the section (Pl. XIV) and suggests that the upper beds are not materially thicker than they are farther east. It is, therefore, significant that at Goginan, as at East Daren, the bottom of the ore-body stands in somewhat close relation to the underground position of this group of dark pyritous shales.

Output.

The Mineral Statistics contain returns of lead-ore from Goginan for the years 1845 to 1886. Messrs. Taylor's reports afford a comparison with these statistics, as they record the sales of ore from 1837 to 1871 and from 1874-77. From the latter half of 1847 to 1860 Messrs. Taylor sold their ore at the rate of 21 cwt. to the ton. This correction has generally been applied in the Mineral Statistics for those years, and the figures given below are all on the basis of 20 cwt. to the ton. Although in individual years the returns in the Mineral Statistics and the sales of ore recorded by Messrs. Taylor differ considerably, there is close



SECTION ALONG LODE FROM GOGINAN TO PENGRAIGDDU, SHOWING
RELATION OF ORE-BODIES TO THE GEOLOGICAL STRUCTURE.

agreement in the total output between 1845 and 1886, the figures being 17,291 tons and 17,257 tons respectively :—

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 17,256 $\frac{1}{2}$	Tons. 12,081 $\frac{1}{2}$	% 70·1	Oz. 170,120 ¹	Oz. 20·6	Oz. 25·3

The available lead was re-calculated for Messrs. Taylor's figures, the same ratios being used as in the Mineral Statistics.

The output of lead-ore from 1837–1844 was 7,851 $\frac{1}{2}$ tons, from which it may be estimated that 5,324 tons of lead was obtainable.

Yield of the ore in the lode.—Messrs. Taylor give some interesting figures which indicate the produce of ore in the lode. In 1843, 1 ton of ore was obtained from 15–20 tons of stuff. In 1846, 38,000 tons of rock were broken and 32,000 tons were brought to the surface; the yield of dressed ore was 1,785 tons, equal to 1 ton from 21 tons broken or 18 tons raised to surface. In 1851, 36,500 tons were brought to surface and yielded 956 tons of ore, or 1 ton from 38 tons.

The area stoped since 1837 is, approximately, 17,000 sq. fathoms; the average yield of dressed ore throughout the Goginan and Bryn-pica workings is, therefore, about 1 ton per sq. fathom. Blende, 60 tons.

BWLCH.

(6-in. Sheet, Card. 7 S.W., Long. 3° 54' 35", Lat. 52° 25' 23".)

This is an ancient mine which lies on the south side of the Cwmerfin valley and about a mile E.N.E. of Goginan. It is referred to by Waller as Cwmerfin mine and by later miners as Bwlch Cwmerfin, Bwlch Consols or (with Bwlchrhennaid) Bwlch United. The only plan of the workings that appears to be in existence is that dated 1846, which is preserved in the Home Office; it is difficult to reconcile it with what is known of the later workings and their relation to those of Goginan just over the boundary on the west, and also of the Ceunant mine on the east.

¹ If the silver in the lead-ore be calculated from the average content the total amount of silver may be estimated as follows :—

1837–1844	-	-	-	-	151,000 oz.
1845–1886	-	-	-	-	346,000 „
Total	-	-	-	-	497,000 „

According to this plan the adit (about O.D. 770), which is driven south-south-west, intersects at about 66 fms. a lode which was followed for some distance east but mainly west, its end being close to the boundary and a few fathoms north of the great opencast working. A shaft was sunk from the surface to a 15-fm. level, which was also driven westward in a position on the whole north of the adit, indicating a slight northerly inclination. The outcrop of what is referred to as the "main lode" is south of the adit and passes through the opencast where the lode divides into two branches diverging at a considerable angle; the adit and 15-fm. level appear to follow the north branch. On the other hand, the lodes within the Goginan boundary, between 30 and 55 fms. below the Bwlch adit, have a decided inclination to the south, and, as the workings are connected with those of Bwlch, it must be presumed that the latter lode at that depth has a similar inclination.

According to A. Francis (p. 46) there are two lodes. On the north or main (supposed Goginan) lode an engine-shaft has been sunk to a depth of 70 fms. under the adit, and in "driving east of the Engine shaft, a new lode was found diverging south from the Goginan vein," which was worked to a depth of 90 fms. under the adit; this was known as the middle lode, the south lode being that referred to as the Level Newydd or Bwlchrhennaid lode.

It appears that the great body of ore worked for nearly 30 years at this mine came from the neighbourhood of the junction of the main and middle lodes, and that they become impoverished towards the Goginan boundary; probably the same thing happened eastward. Two shafts, about 20 and 40 fms. from the opencast, were connected with this body of ore, while another vertical shaft about 100 fms. farther east, is believed to be on the middle lode, the outcrop of which must pass some distance to the north. The main lode is said to be that which is exposed with a southerly dip of about 75° in the south side of a quarry, about 50 fms. west of this shaft.

With the returns from this mine are included those from Bwlchrhennaid, which lies within the same sett.

Bwlchrhennaid.—This is a small mine worked by a shaft sunk on the Level Newydd lode. It appears to have been worked by Sir Humphrey Mackworth and the Mine Adventurers about 1700. Reference to the plan shows that the workings were limited in depth, as well as along the extension of the lode, by the form of the sett-boundary. Accordingly, the 72-fm. level is the deepest in the mine; the 50- and 60-fm. levels were driven east and west to the boundary, but the 72-fm. level has only been extended about half-way; there was ore left in the sole of this level, capable of yielding from 1 to $1\frac{1}{2}$ tons per fm. and extending for 35 fms., but as regards the present boundaries of the sett, the mine is practically exhausted.

Output.

Returns of lead-ore from Bwlch were made in the years 1845-75, 1880-83. There is also a return of silver alone for 1885 :—

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 7,750	Tons. 5,699½	73·5	Oz. 74,784 ¹	Oz. 13·5	Oz. 18·2

Before discussing the relation of the Goginan workings to those of Bwlch and the adjoining mines, a brief description of some other mines is appended.

LEVEL NEWYDD.

East of the Bwlchrhennaid boundary the lode has been dug along the outcrop for a distance of over 100 fms. Prior to 1843 it had been worked by an adit cross-cut called Levelyrhych (about 910 O.D.), which was driven westward to the Bwlchrhennaid shaft and about 80 fms. eastward. Several small bunches were stoped away almost to the surface.

In 1842 Messrs. Taylor commenced another adit cross-cut, called Level Newydd or New Level, farther east and at a lower level (about 700 O.D.), and in 1844 cut the lode at 82 fms. from the mouth and 50 fms. below the surface; it had a width of 7 to 8 ft., but did not prove very productive. About 1863 and later years a shaft was sunk from the surface to the upper adit and through old workings down to a 70-fm. level; the lode in the shaft yielded on an average 18 cwt. of lead-ore per fm.; the levels below the adit gave from 16 cwt. to 1 ton per fm. In the bottom or 70-fm. level a run of ore-ground 30 fms. in length was passed over, which yielded at several points 12 cwt. per fm. The level was driven to within 12 fms. of the Bwlch workings and then suspended, the men refusing to work until the water had been pumped out of those workings. Nothing has subsequently been done in that mine until 1919, when the old workings were being cleared. Small quantities of ore appear to have been got annually between 1844 and 1864, but separate returns were only made in 1852 (75 tons) and 1853 (25 tons); these are included in the Goginan returns.

It may be estimated that about 300 tons were obtained altogether during this period. All the work was probably done on tribute.

¹ If the silver be calculated on the total yield of ore, the probable amount is 104,200 oz.

PENGRAIGDDU.

This mine lies on the Level Newydd lode, and a quarter of a mile east of that mine. Waller gives a section of a mine under this name, which is, however, difficult to interpret unless the north and south cardinal points are interchanged in his diagram. He shows an adit which had been driven at that time about 50 fms. on a lode containing 10 in. of ore. Another lode, 3 to 5 ft. wide, mixed with ore and veinstone throughout its breadth, is indicated at a distance of 30 yds. to the north. This contained in several places clean ribs of ore 9 in. wide. The ore is said to have yielded 44 oz. of silver from each ton of metal. The depth of the adit below the surface was 32 fms. If the cardinal points be interchanged this description probably applies to the adit (about 980 O.D.) driven westward from the steep western slope of the Melindwr or Cwm Graig valley (Llettymarallt adit). The shallow workings suggest that two lodes had been excavated along the outcrop at a distance of 20 to 25 yds. apart. The workings were carried on from a shaft, the water and ore being drawn by a horse-whim. Much of the ore was, in ancient times, dressed by hand on the spot, but in later days it was carried several miles on horseback to Llawcrembach to be dressed there. In the shaft a lode, consisting of about 2 ft. of breccia, is exposed with a southerly inclination of about 80°.

According to A. Francis, workings extend 12 fms. under the adit, which is 30 fms. below the surface. He states that "an excellent course of rich lead-ore is left at the bottom" of the mine.

The Level Newydd lode, when traced eastward towards Pengraigddu, appears to split about 150 yds. west of the latter mine, the main portion of the lode being on the north. This agrees with Waller's description.

The Llettymarallt adit, which has recently been cleared, has been driven obliquely into the hillside in a direction W.N.W. for a distance of 85 fms. At 36 fms. from the mouth a soft lode, consisting of crushed pale-green mudstones, has been followed apparently as far as the shaft, but owing to a fall in the roof is not accessible beyond a point about 76 fms. from the cross-cut.

CEUNANT.

This is an old mine in which little work has been done within living memory. There are three adits: the upper, about 15 fms. below the surface; the middle, about 30 fms. deeper and the deep adit, about another 22 fms. deeper. According to A. Francis the middle adit (about 980 O.D.) has been driven a great distance on the lode, and the principal returns were made from it, while the lower or deep adit (about 870 O.D.) has been driven about 150 fms., principally on the course of the lode, and a communication effected with the middle adit and some

underhand stopes about 6 fms. below it. The ore was a fine-grained "steel ore," similar to that of Goginan.

The lode is believed to be the easterly continuation of the Bwlch main lode or supposed Goginan lode, and there is much similarity between the ore from these mines. In other respects, however, the lode both at Bwlch and Ceunant is of the type that is commonly thrown off as a branch from a powerful master-lode. At Ceunant it appears as a nearly vertical, narrow lode, consisting of brecciated pale mudstone with strings and spots of galena; in traversing the adjoining rocks it scarcely produces a displacement, and is, therefore, of the nature of a joint-lode, whereas at Level Newydd and Pengraigddu that lode is accompanied by a throw of the adjoining rocks of about 40 yds. to the south.

An examination of the deep adit which has recently (1919) been partially cleared, shows that the lode carried small bunches of "steel-ore," either forming a narrow rib or mixed with quartz; the hade is small but variable, being in some places to the south-east and in others to the north-west. About 80 to 100 fms. from the mouth another lode, with a slight southerly hade and ranging a few degrees north of east, has been stoped for a few feet; it carries a solid rib from 2 to 2½ in. wide of "steel-ore." The relation of this to the one on which the adit has been driven is not known.

RELATION OF THE GOGINAN WORKINGS TO THOSE OF BWLCH, LEVEL NEWYDD AND PENGRAIGDDU.

The main Goginan workings lie to the west of a group of mines which have been developed on a lode-belt ranging approximately west-south-west; these are Brynpica, Bwlch, Bwlchrhennaid, Level Newydd (or New Level) and Pengraigddu. These workings correspond to several distinct ore-bodies, and the levels driven through to Brynpica from Goginan passed through about 150 fms. of barren ground.

The Bwlchrhennaid and Level Newydd workings are on one ore-body and would naturally have been developed together if it had not been for the peculiar shape of the sett-boundary, which runs nearly parallel to the outcrop of the lode. Although no connection between Level Newydd and Pengraigddu has been made underground, it is obvious at the surface that the same lode traverses them, though barren ground intervenes between the ore-bodies.

The relation of the lodes on which these workings are situated has never been adequately cleared up, although many trials to that end were made in the workings from the Brynpica and Boundary shafts. It has been the prevalent belief that there are three distinct lodes, viz., the Goginan main lode, the Bwlch middle lode, and the Bwlchrhennaid or New Level lode as it may be called. The Bwlch north lode lies almost exactly in line with the Goginan main lode, and was believed to be its easterly

continuation. The New Level lode has always been regarded as distinct from the Goginan and Bwlch lodes and was supposed to lie some distance to the south of them.

A full consideration of the surface-evidence and of all available plans leads to a different conclusion, viz., that the Goginan main lode and the New Level lode are continuous, but that the Bwlch north lode forms a junction with it, probably a little to the west of the Brynpica shaft. The Bwlch middle lode springs off in turn from the north lode near the Goginan boundary. The Goginan-New Level lode may be regarded as the principal or master-lode, and the Bwlch lode as an offshoot from it. The evidence for this conclusion is given in some detail (*see* Pl. XXVII.).

Although no plan of the Bwlch workings is available except one dating from 1847, when little work had been done below the adit, it appears that, within a width of about 40 fms., there are two, if not three nearly parallel lodes. The middle, and possibly the north, lode have been worked in a large open-cast immediately east of the Boundary shaft, and according to Messrs. Taylor's reports it was on the middle lode that the Boundary shaft was sunk. At the appropriate depth a cross-cut was driven northwards from this shaft to communicate with the Bwlch adit. Cross-cuts to the north, at 30 and 55 fms. below the Bwlch adit, met a lode at distances from the shaft of 12 fms. and 4 fms. respectively. This lode dips to the south at an angle of about 73° , and its surface position must lie some distance north of the great open-cast. It may, therefore, be identified as the Bwlch north lode. The 55-fm. level was, subsequently, driven westward on it and into communication with the Brynpica shaft; the lode deteriorated rapidly, however, after crossing the boundary. The outcrop of this lode must be about 15-18 fms. north of the 55-fm. level and as the lode on which the Brynpica shaft was sunk occupies exactly this position, it, also, can be identified with the Bwlch north lode. There is no evidence that any work was done on the lode on which the Boundary shaft was commenced; in other words, the Bwlch middle lode.

The Brynpica shaft, when it was being sunk in 1852, was believed to be on the Goginan "main" lode, on which the deep adit was at that time being driven eastwards at a point less than 120 fms. distant. The adit was then passing through the Brynpica ore-body, which was discovered in driving eastward on the lode from the Goginan main workings. Subsequently (1853), Messrs. Taylor state that "it is now perfectly clear that the lode upon which the deep adit is driving is to the south of the lode upon which we are sinking the Brynpica shaft, the back of the south lode" [namely that in the adit] "having been recently discovered about 35 fms. south of the Brynpica shaft, and it corresponds according to the underlie with the lode which has been driven upon in the deep adit level; so that a cross-

cut must be driven north to intersect the north lode [Brynpica shaft lode] somewhere opposite the Brynpica shaft." Thus in the neighbourhood of the shaft two lodes had been proved at the surface; when the deep adit was communicated to the shaft the above-mentioned cross-cut was driven north for 50 fms. in order to intersect the north lode, in the belief that the deep adit was still on the same lode as it was when the above statement was made; nothing was met in the cross-cut, although it was driven to a point well to the north of the surface position of the shaft. It is now clear, however, that the deep adit when it reached the bottom of the shaft was already on the lode which outcrops at the top, and on which the 55-fm. level had been driven. Reference to the plan shows that the course of the deep adit from Brynpica eastward to the boundary shaft is parallel to that of the 55-fm. level, and the distance apart of these levels agrees with the position assigned to the outcrop of the lode on which the shaft was sunk. The south lode, which had been proved at the surface, lay, therefore, about 35 fms. to the south, and the adit must have departed from it at some point between 30 and 40 fms. west of Brynpica and had then followed the other lode to the bottom of the shaft. It is significant that about 37 fms. west of the shaft the lode in the deep adit became soft and unproductive. About 35 fms. east of the shaft a cross-cut was put out nearly 30 fms. south from the adit, but met nothing; on the view expressed above, the south lode would lie about 35 fms. south of the deep adit, so that the cross-cut probably fell just short of proving it. A confirmation of this view was obtained at the boundary-shaft where a cross-cut was driven south at the 55 fm. level and in 36 fms. cut a lode 20 or 30 ft. wide which contained "the peculiar white stone characteristic of the Goginan and other silver-lead lodes in the district."¹

The position of this lode with reference to the Brynpica shaft lode and its direction agrees with the surface position of the south lode of Brynpica, which is here identified as the main lode of Goginan. At that time this south lode was believed to lie to the north of the New Level lode which was worked at New Level and Bwlchrhennaid; the 55-fm. cross-cut south from the boundary-shaft was, therefore, extended another 40 fms. to search for that lode, but without result. Moreover, a cross-cut south from the deep adit at about 50 fms. west of Brynpica shaft in search of the same lode met nothing after driving 101 fms. The explanation of these failures is now clear. There is little room for doubt that the lode intersected in the 55-fm. cross-cut is the New Level lode; its position and direction in the levels which were driven upon it correspond closely with its position at the surface and in the underground workings of New Level and Bwlchrhennaid. The failure of the 101-fm. cross-cut from the adit west of Brynpica shaft to cut the New

¹ Messrs. Taylor's Reports.

Level lode is due to the fact that the deep adit at that point was on the united Bwlch and New Level lodes, but east of that point the two lodes parted and the main adit turned off along the northern branch or Bwlch north lode. This explanation obviously accounts also for the failure of the cross-cut north at Brynpica shaft to cut the Bwlch north lode. The only evidence that appears to contradict the view just stated is that the New Level ore is said to have contained much less silver than the Goginan and Brynpica ores, but, on the other hand, the Pengraigddu ore on the same lode a short distance to the east is again highly argentiferous.

It is unfortunate that the boundaries of the properties traversed by these lodes ran in such a way as to have prevented the systematic exploration of this area from the Goginan end, where the deep adit afforded a means of unwatering the ground to a greater depth than could be obtained by any other adit.

CWMBRWYNO.

(6-in. Sheet, Card. 7 S.W., Long. $3^{\circ} 53' 35''$, Lat. $52^{\circ} 24' 33''$.)

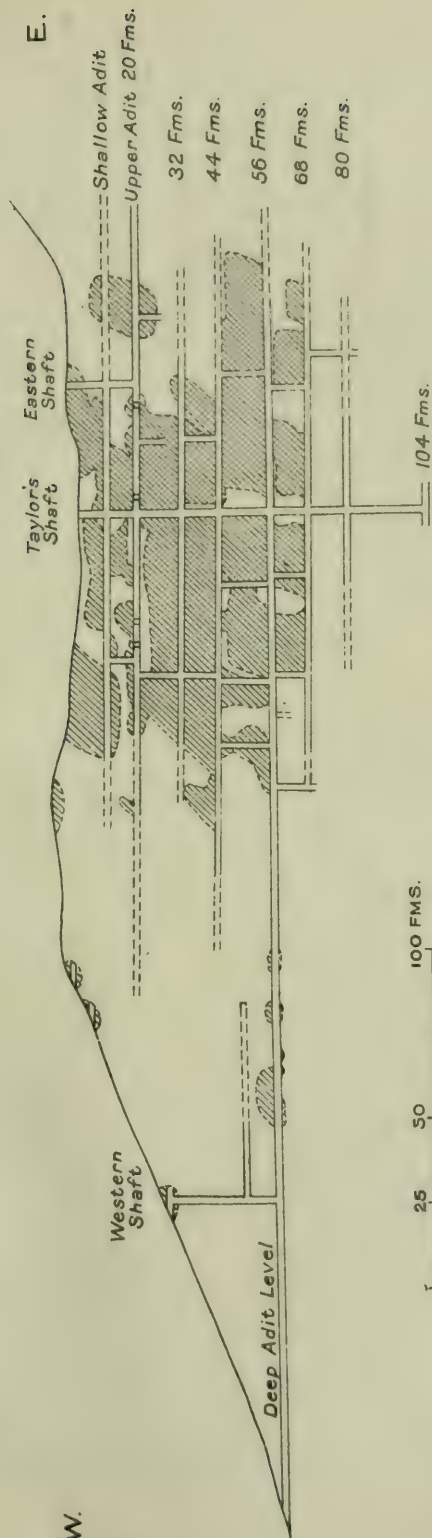
This mine lies on Cefn Brwyno hill, half a mile east of the Aberystwyth-Llanidloes main road and about 9 miles by road from Aberystwyth. It appears to have been discovered about 1840, but only produced ore in any quantity 12 years later. It was worked by Messrs. Taylor & Sons for many years until 1866, and the only available plan and section of the workings probably dates from about that period, but as four-fifths of its total output had been produced by that time, subsequent developments are not likely to have been extensive.

The lode dips to the south at about 55° and trends on the average west-south-west, but in the neighbourhood of the main workings it exhibits a characteristic swerve, which not improbably was favourable to the deposition of the ore.

The mine was, at one time, drained by shallow adits, one about 1060 O.D. and an upper adit or 20-fm. level about 1010 O.D. Later a deep adit or 56-fm. level was driven eastward by Messrs. Taylor from near the Aberystwyth main road. It intersected the lode near the western shaft, which is sunk to the adit about 100 yds. east of a small chapel; its mouth is about 745 O.D., but it rises considerably and at the main shaft it is about 780 O.D. (Pl. XV.).

Taylor's shaft, from which most of the workings were carried out, was sunk on the lode to the 44-fm. level; below that depth the lode lies south of the shaft at a distance which increases with the depth, and is reached by cross-cuts, that at the 80 fms. being over 10 fms. in length. Levels were driven at each 12 fms. below the 20-fm. or upper adit. After Messrs. Taylor relinquished the mine, Taylor's shaft was deepened to about 104 fms.

The mine lies in the lower part of the Frongoch formation and is approximately midway between two well-marked anticlinal axes. The ore-body is about 120 to 160 fms. in length



LONGITUDINAL SECTION OF CWM BRWYNO MINE.

in each of the levels down to 68 fms.; some ore was found also at the surface and in the adit as far as the western shaft, about 120 fms. west of the main body. Although the ore is fairly continuous, there is some indication on the section of shoots dipping steeply westward.

The average yield of the part of the mine worked by Messrs. Taylor was nearly one ton per square fathom.

Output.

Lead-ore was returned in the years 1845–1878, 1880–82, 1888 :—

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 6,095	Tons. 4,552 $\frac{1}{4}$	% 74·7	Oz. 7,383	Oz. 2 $\frac{1}{4}$ ¹	Oz. 3

Blende was returned in the years 1854–60, 1861, 1865, 1866, 1870–73, 1882, 1888, 1892. Total, 796 tons.

BOG OR CRAIGNANT BACH.

(6-in. Sheet, Card. 7 S.E., Long. 3° 51' 15", Lat. 52° 24' 55".)

This is a small mine lying three-quarters of a mile west-north-west of Ponterwyd, and about a mile and a quarter distant by road. It was at one time held together with Daren and some others under the name of the Gogerddan mines. There is no plan available later than that dating from 1845, which is preserved in the Home Office. The lode strikes W. 15° to 20° N. and dips to the south at 60° to 65°; in 1845 the shaft had only been sunk to the 24-fm. level below the shallow adit, which was about 7 fms. below the top of the shaft; the mine has undoubtedly been deepened considerably since that time, as it was working intermittently until 1883, and is generally understood to have been for its size a rich mine. There are two parallel lodes visible at the surface; one east of the shaft dipping southwards at 50°, and the other, which contains some lead-ore, south-west of the shaft. On the above-mentioned plan there is a cross-lode indicated in the 12-fm. level which ranges about W. 35° S. The lode at Bog is said to be the same as that of Llywernog, which lies half a mile away in a direction W. 28° S. This does not agree with the direction of the lode shown on the older plan, but it is possible that the main lode at Bog may have proved to be the cross-lode cut in the 12-fm. level, which strikes approximately in that direction.

¹ It is doubtful if such a low yield of silver would be worth extracting. With these values the total amount of silver in the ore may be estimated as 13,600 oz.

Output.

Between 1845 and 1850 this mine was included with Daren as the Gogerddan mines, but whether any ore was derived from the latter mine is not known. There is a separate return for Daren for 1849 and 1850; the amount is considerably less than for the Gogerddan mines for those years. Since 1850 there are returns from Bog for 1853, 1858, 1871-73, 1882, 1883:—

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton.
Tons. 1,542 $\frac{1}{4}$	Tons. 1,082	% 70·1	Oz. about 2 ¹	Oz. 3

¹ The ore is so poor in silver that it would not be extracted.

Blende was returned in 1857, 1871 and 1872. Total, 702 tons.

LLYWERNOG OR LLEWERNOG.

(6-in. Sheet, Card. 7 S.E., Long. 3° 52' 10", Lat. 52° 24' 37".)

Two separate mines are included under this name. They lie between the 10th and 11th milestone on the Aberystwyth-Llanidloes main road, which runs through the western or Powell's mine; the other is about 300 yds. to the east on the opposite side of the valley, and is known as Poole's mine or Llywernog. They have sometimes been worked separately, at other times together, under the name of Powell Consolidated or Powell's United. In some years they were called the Ponterwyd mines.

The plan of Powell's mine cannot be found and the only available plan of Poole's mine dates from about 1866; it does not appear to be reliable in some respects.

At Poole's mine there is a vertical engine-shaft to a depth of 72 fms. and levels at 20, 30, 40, 50, 62 and 72 fms.; a shallow adit enters from the pit for the 60-ft. wheel which operated the mine. Two lodes were met in the mine which converged eastward at the engine-shaft; the 30-, 40- and 50-fm. levels have been driven westward partly on the south but mainly on the north lode; the 20-fm. level follows the former, but a cross-cut north about 40 fms. west of the shaft intersected the other lode in about 13 fms.

The junction of the lodes is indicated on the longitudinal section as occurring between the 40- and 50-fm. levels. There is evidence at the surface of two distinct lodes uniting near the engine-shaft; one can be traced westward for about 40 fms. from the shaft by the collapse of stopes over a shallow level and eastward along the base of the slope on the north side of the valley as far as an old shaft 300 yds. north-west of the Gogerddan Arms Hotel, Ponterwyd, where its intersection

with the Brynglas lode is exposed. It there strikes W. 15° N. and dips northward at about 80° . This appears to correspond with the "north lode" of Poole's mine; the south lode ranges for Powell's mine and is said to be the main lode worked therein; in the opposite direction it ranges towards the Bog mine.

In an old leet about 200 yds. to the northward of the shaft, a lode is visible striking W. 5° S. and dipping to the north at about 70° , which is said to be the Nantyrarian lode.

At Powell's mine the Llywernog (supposed Bog) lode is exposed in a wheelpit and close to the road a shaft has been sunk on it to a depth of 30 fms. From this point it strikes towards another shaft 200 yds. to the south-west which is 70 fms. deep, but as the main lode is joined thereabouts by another which ranges east-and-west and dips to the north, it is not certain on which lode the shaft was sunk. A vertical shaft 100 yds. to the east is 50 fms. in depth.

The east-and-west lode is visible in the side of a small quarry 180 yds. east of the 50-fm. shaft; it dips steeply to the north and carries a small rib of blende. A. Francis (p. 35) describes the lodes as follows: "There are three veins known as Crosby's, Smith's and the North lodes, the two latter forming a junction in going eastward and east of the turnpike road . . . , and these two again form a junction in going westward at different points with Crosby's lode, and between these two junctions at Crosby's the greatest and richest course of lead ore have [has] been found. These junctions occur at about from 40 to 50 fathoms. apart, and between them the ore will yield on an average nearly 3 tons per fathom." He states further that Crosby's lode has been traced westward into the Cwmbrwyno mine.

From the fact that the Cwmbrwyno lode dips southward, as apparently does also the Llywernog main lode, while the other lodes all dip to the north, it is probable that "Crosby's lode" is the main Llywernog-Bog lode.

Output.

The Llywernog mines returned lead-ore, either from one or both mines, in the years 1845, 1857, 1864-78, 1880-90:—

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 3,813 $\frac{1}{2}$	Tons. 2,837	% 74.4	Oz. 4,260 ¹	Oz. 3.6	Oz. 5.5

Blende was returned in the years 1859, 1865, 1868, 1870, 1873, 1875-78, 1881-90. Total, 560 tons.

¹ Returned for eight years only. The silver corresponding to the total output may be estimated at about 14,600 oz.

BWADRAIN.

(6-in. Sheet, Card. 7 S.W., Long. $3^{\circ} 53' 42''$, Lat. $52^{\circ} 24' 0''$.)

This mine is about three-quarters of a mile south of Cwmbrwyno, and about half a mile north of the Rheidol valley, 2 miles below Devil's Bridge. The only approach to it is by a cart-track from the main road to Aberystwyth near Cwmbrwyno mine, a distance of about a mile. The shafts are situated on a peat-flat about 900 ft. above sea-level, which necessitated a special device for pumping; a waterwheel was erected in the Rheidol valley about 700 ft. below, and a line of rods nearly half a mile in length was carried up the steep slope of the valley to the pumping-shaft. In spite of these handicaps a considerable amount of lead-ore was raised from it in 10 years.

The workings are situated at an abrupt bend or elbow in the lode, which is said to dip south at an angle of 45° to 50° ; the pumping-shaft is on a part of the lode which strikes about W. 35° S., but in another shaft 100 yds. to the west it strikes a few degrees north of west. Near the road-fence a winze is sunk from the surface at the point of intersection of the two parts of the lode.

Although lead-ore was sold almost exclusively, the lode is rich in blende and the waste-heaps near the engine-shaft contain a considerable amount of blende-rock, some of it with a high content of mineral. Most of the blende-ground was not broken.

In view of the moderate southerly dip of the lode, the mine is favourably situated for a deep adit from the Rheidol valley which would drain the workings to a depth of over 110 fms. below the surface. Such an adit might expect to meet the lode in 150 to 200 fms.

The Bwadrain lode is supposed to be continued into the small Gelli or Gelli'reirin mine where a deep adit (about 250 O.D.) has been driven eastward for some distance towards the former. A suggestion has been made to extend this adit under Bwadrain.

On the slope of Coed Dolfawr near the feature known as "the stag" there are two lode-outcrops; one of these has been worked near the rump and head of the "stag," and it is mainly the débris from these workings that form the bare patch on the hillside which bears a resemblance to that animal. Between the antlers there is a deep hole where a lode is exposed dipping south at about 55° ; it strikes towards, and is probably continued into, the western branch of Bwadrain, which it resembles also in its low inclination. This appears to be the main lode worked at Gelli'reirin. There is evidence of another lode nearly 150 yds. to the south which strikes approximately for the eastern branch of Bwadrain. It is probable, therefore, that Bwadrain is situated at the junction of these two lodes.

Output.

The mine returned lead-ore annually from 1867-76.

Lead-Ore.	Lead.	Ratio.	Silver. ¹	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 1,744	Tons. 1,322½	% 75·8	Oz. 9,902	Oz. 12·6	Oz. 16·8

Blende was sold in 1873 only. Amount, 5 tons.

PLYNLIMON.

(6-in. Sheet, Card. 5 S.W., Montgomery, 40 S.W.,
Long. 3° 46' 25", Lat. 52° 27' 20".)

The Plynlimon mine is near Afon Tarenig, a mile and a quarter north of Eisteddfa Gurig, on the main road from Aberystwyth to Llanidloes.

The nearest station is Devil's Bridge on the Vale of Rheidol branch of the Cambrian Railway and about 8 miles distant; Llanidloes station is 15 miles distant by road and Aberystwyth 18 miles. The mine stands at an altitude of about 1,750 ft. above sea level, and in the Upper Van rocks. These are folded into an anticline, the axis of which crosses the eastern end of the mine.

The plan of the workings cannot be found, and the only available information is contained in a brief report by Mr. John Roberts of Nantgarw mine, Rhayader, dated 18th September 1895, which was kindly lent by Mr. W. Mills, Llanidloes.

The lode dips to the south and there are two shafts on the outcrop. The western shaft is near the stream and the eastern at a higher level about 230 yds. to the eastward. The main level appears to be the 36-fm., but a winze is sunk below this to a 48-fm. level which has been driven for some distance eastwards and westwards in the lode; the winze is apparently near the western shaft and in it the lead-ore formed a rib from 4 to 7 in. wide. The eastern shaft is said to be down to the 48-fm. level, but that level has not been driven. The 36-fm. level was in a course of ore for a distance of 60 fms. The ore in the 48-fm. level west of the winze was estimated to yield from 2 to 2½ tons per fm.; that east of the winze about 1 ton. It is said by some miners who worked there that the lode in the deeper workings was pinched out on entering beds of grit.

About 500 yds. north of the eastern shaft the grits of the Lower Van formation outcrop in the core of the anticline at an elevation of about 2,000 ft.; in the crest of the fold, near the shaft, these grits are probably about 1,650 ft. above Ordnance Datum. From the axis they dip towards the western shaft, but

¹ No estimates for silver are given in the earlier years; the probable total amount is about 22,000 oz

a little to the west of that shaft they encounter a synclinal axis and dip in the opposite direction. At the shaft they are about 1,200 to 1,250 ft. above Ordnance Datum, while the 48-fm. level may be estimated to be about 1,470 ft. or 220 ft. above the grits. These rocks probably cross that level about midway between the two shafts. Their influence on the lode has not apparently been fully tested, the driving of the levels having been stopped when they entered the hard ground.

Output.

Lead-ore was returned in the years 1866-78, 1887-91, 1895. The highest output was 404 tons in 1874.

Lead-ore.	Lead. ¹	Ratio.	Silver. ²	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 3,270½	Tons. 2,439½	% 74·6	Oz. 2,555	Oz. 3·8	Oz. 5

ESGAIRLLE OR OLD ESGAIRLLE AND GREAT WEST VAN.

(6-in. Sheet, Card. 8, Montgomery 46 N.W., Long. 3° 46' 40",
Lat. 52° 25' 45".)

These mines lie near the main road from Aberystwyth to Llanidloes and between the 15th and 16th milestones from Aberystwyth. The nearest station is Devil's Bridge, about 6 miles distant.

Of the two mines the one usually known as Old Esgairlle is on the east slope of the valley about 400 yds. north of Cwm-ergyf farm; the other is on the opposite side of the valley and adjoins the main road. After the discovery of the ore at the Van the latter was known from 1873 onwards as the Great West Van, and was believed to be on the Van lode; this, however, is clearly not the case.

There are no plans of the western mine available. A prismatic compass survey of the Old Esgairlle adits was made in 1918 with the assistance of Mr. W. Griffiths, Dyffryn Castell.

Old Esgairlle.—There are two adits now open, a third which cannot be entered and a fourth which opens directly into stopes. This last or upper adit is about 1,250 ft. above O.D., and is on what may be called the north lode; the middle adit is on the same lode and is about 1,195 O.D.; the bottom adit is on the middle lode, and its mouth is about 1,115 O.D. There is a third adit to the north lode about 60 yds. farther north, but its

¹ There is an error in the lead returns for 1871: Lead-ore 277; lead 307 tons 15 cwt. The latter figure should be 207 tons 15 cwt., and has been corrected in the figures given above.

² Silver was returned for four years only; the silver equivalent of the total amount of ore may be estimated at 12,280 oz.

mouth is blocked. About 14 fms. south of the bottom adit there is a shaft on a third or south lode; the relations of these lodes to one another is revealed in the bottom and middle adits.

In the middle adit a lode has been stoped, both above and below, for about 5 fms. to the east of the upper adit. It ranges E. 22° S. and dips to the south at a steep angle; 32 fms. from the mouth it is crossed by the middle lode which is about 5 ft. wide, strikes E. 16° N. and dips to the south at 80° . About 16 fms. farther there are stopes and some workings under the adit on a rather pyritous lode; beyond those workings which are about 30 fms. in length, the adit has been driven for 28 fms. along a clayey lode dipping southwards, but the floor is covered by a thick deposit of ochre, which increases in depth inwards. At about 115 fms. measured along it from its mouth, the adit divides into two branches, but both are inaccessible; it is said that there are other workings beyond that point.

The bottom adit has been driven on an indefinite lode, which, however, improves in appearance inwards; about 50 fms. from its mouth it has been driven on a lode dipping S. at about 80° , which enters at that point; this may be the south lode worked in the shaft. About 66 fms. from the mouth of the adit it is crossed at a large angle by the north lode, which has been stoped eastward for a total length of about 15 fms.; the walls of the former continue through the footwall of the latter, and correspond with its position in the middle adit. About 18 fms. east of the point of intersection, the adit is blocked at a point where a winze descends from the middle adit. It must continue for at least 35 fms. as there are workings from it to the floor of the higher adit.

The shaft appears to have been sunk on a distinct lode which may be the one that joins the north lode about 58 fms. from the mouth of the middle adit; this lode carries a considerable amount of marcasite and is probably responsible for the ochreous water which issues from the east end of that adit.

The chief interest of these adits is their relation to the Castell lode, the outcrop of which crosses the hill in advance of them from Cwmergyr to the Tarenig valley. The end of the accessible portion of the middle adit is about 40 yds. west of the nearest point on the outcrop of that lode, or about 50 yds. measured in the direction of the adit; as the Castell lode dips S.E., its underground position would be about 15 to 20 yds. farther east. It is therefore quite possible that the middle adit has been driven to the intersection of the north lode with the Castell lode, and it is unfortunate that access cannot be gained to the end of the level, as nothing is known of the character of the Castell lode in this locality.

The upper and middle adits are driven in the basal beds of the Frongoch formation; the bottom adit commences in the Gwestyn rocks and enters the overlying formation, which dips eastward.

Esgairlle or Great West Van.—Two lodes outcrop at the surface within the loop formed by the main road near the mine-buildings; one ranges approximately east-and-west, and appears to be the combined middle and south lode of Old Esgairlle; the other ranges N.E.—S.W. towards the broad valley of the Castell and almost parallel to the strike of the country-rocks, which belong wholly to the Gwestyn formation. The lodes intersect above the road near some ancient workings, where a number of rounded “bucking stones” indicate the primitive methods adopted for dressing the ore by hand.

There are several adits on the N.E.—S.W. lode, the principal one being about 1,040 O.D. About 110 yds. north-west is a vertical shaft which is drained to a depth of about 10 fms. by a shallow adit (about 980 O.D.); it is between the two lodes and both were probably worked from it. The large dumps of rusty shales prove that the workings were on a considerable scale. The lode-matter consists of breccia of Gwestyn rocks cemented by quartz and calcite; galena is associated with a fair proportion of blende and there appears to be a good deal of ore in the dumps.

Output.

Returns for Esgairlle were made in the years 1850–54, 1856, 1857, 1865, 1867, 1869–73, and for Great West Van in the years 1873–77, 1880–82, 1884, 1890–92 :—

—	Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
	Tons.	Tons.	%	Oz.	Oz.	Oz.
Esgairlle -	1,255 $\frac{3}{4}$	925	73·6	—	—	—
Great West Van	813 $\frac{1}{2}$	623	76·6	2,239 ¹	4·3	5·6
Total -	2,069 $\frac{1}{4}$	1,548	74·9	2,239	4·3	5·6

Blende.—Only 7 tons of blende were returned in 1865.

CASTELL (KNOWN ALSO AS WEST ESGAIRLLE, DYFFRYN CASTELL, NEW CASTELL AND LOCALLY AS CRIPIAU BACH OR GWAITHDU).

(6-in. Sheet, Card. 8 S.W., Long. 3° 48' 12", Lat. 52° 24' 53".)

This is a small and shallow mine which works the Castell lode on the south side of the valley near Dyffryn Castell, 14 miles from Aberystwyth on the main road to Llanidloes; it is about 4 miles by road from Devil's Bridge. The country-rocks on the south side are the lower beds of the Frongoch formation, those on the north are the Gwestyn shales.

¹ Returns for seven years only. The total amount of silver corresponding to the output of ore at Great West Van is about 3,480 oz.

The Engine-shaft is about 27 fms. deep, but at present the water is only drawn from the 20-fm. level; an adit cross-cut (about 960 O.D.) drains the mine to about 7 fms. below the surface at the shaft. The 10- and 20-fm. levels have been driven nearly 80 fthms. east and about 50 fms. west; and in the former several cross-cuts north and south have been put out to test the lode, which is in places 10 to 15 fms. in width. It consists of brecciated rocks partly derived from the hanging wall and partly from below the footwall. A large body of blende has been worked away from the surface to the 20-fm. level in a wide opencast east of the shaft. The main mass of ore appears to be in the middle of the lode, which strikes towards the centre of the Castell valley, but in the ravine east of the mine the main displacement associated with the lode is far to the south of that strike, and it is probable that a sudden deflection southward takes place near the east end of the opencast. There is evidence of a similar change of strike in the 10-fm. level, where at one point the footwall strikes E. 20° N. and 18 fms. to the east it strikes E. 10° S. As in so many other instances in the district the ore-body appears to be associated with a swerve of the lode. It is possible that at the point of deflection a branch goes off along the Castell valley in the direction of Great West Van.

At the east end of the 10-fm. level the lode near the footwall contains calcite, gossany quartz and blende; in the 20-fm. level a clay- or flucan-band traverses the lode obliquely and, in approaching the footwall eastward, appears to cut out the mineral. In the 20-fm. level under the east end of the opencast the blende terminated downward against a gently-sloping unbroken bedding-plane; it was, however, continued a little farther south. The heave was probably an original feature of the deposit and not caused by a subsequent movement.

Near the Engine-shaft a cross-cut south from the 10-fm. level cut a narrow lode carrying galena, which has been worked to a small extent. So far as it has been explored, the ore at Castell appears to be restricted to a length of about 110 to 120 fms. near the Engine-shaft; it is considerably shorter than this in the 20-fm. level.

That shaft is sunk to the west of a synclinal axis, which traverses the Frongoch formation; about 220 yds. farther east is an anticline in the core of which the Gwestyn rocks outcrop south of the lode. The ore-body lies mainly in the flanks and bottom of the syncline.

Output.

Lead-ore.—There are returns for the three years 1874, 1898 and 1916. Total, 139 tons, but the 1874 return appears to be in error, as 109 tons were valued at 330*l.*, agreeing with the price of blende for that year.

Blende.—Under various names there are returns of blende for the years 1857, 1859–61, 1865, 1871, 1872, 1874, 1876–80, 1882,

1884, 1886-90, 1894, 1895, 1899-1908, 1910-14, 1916, 1917 (39 years). Total, 5,365 tons.

Copper-ore was found in a shaft half a mile east of the Castell mine (this shaft was also called West Esgairlle). In 1874, 25 tons of ore were returned, containing $1\frac{3}{4}$ tons of copper.

Silver was returned in 1874 and 1916. Total, 435 oz.

ABERYSTWYTH MINES.

(6-in. Sheet, Card. 11 N.E., Long. $3^{\circ} 51' 30''$, Lat. $52^{\circ} 22' 30''$.)

These mines consist of Penrhiw and Bwlchgwyn, which are in, and to the east of, the village of Ystumtuen. Bwlchgwyn has been worked for a considerable period; it was at one time known as Nanteos or Nanteos Consols. Both mines lie on the Castell lode, which is of considerable width and dips to the south at about 65° . The workings are drained to a depth of about 40 fms. beneath the surface by an adit (upper adit), which has been driven eastward from the Ystumtuen or Cwmrheidol mine. Bwlchgwyn was worked from a shaft which is about 200 yds. to the eastward of Penrhiw and is sunk to a depth of 50 fms. The longest level is the 30-fm., which has been driven about 145 fms. to the eastern boundary; westwards it communicates by a ladder-way with the adit near Penrhiw. The 40-fm. level connects directly with the same adit. Near the eastern boundary the drivages have been turned out of the course of the main lode along what appears to be a branch, ranging nearly east-and-west and dipping steeply to the south; this branch is exposed in the top of an old shaft which has been sunk to the 20-fm. level. Farther east the main lode has again been worked in the adjoining Llwynteify mine, where it is said to have yielded a considerable amount of ore.

Penrhiw mine is worked from a shaft which is sunk to a depth of about 40 fms. below the adit or 86 fms. from the surface. The workings lie mainly to the west of the shaft and extend nearly to the boundary between this mine and Ystumtuen. Although galena is the principal product, certain parts of the lode carry a considerable quantity of iron-pyrite and marcasite. Most of the lead-ore which has been obtained during the last few years was got from a branch lying somewhat to the north of the main lode, and is free from admixture with the above-mentioned minerals. The ore-bodies which are revealed in the workings of these two mines are somewhat irregular in form, and their length in the deeper levels seems to be considerably less than near the surface. Little work has been done at Penrhiw below a depth of 50 to 60 fms. from the surface, but both this and Bwlchgwyn could, if necessary, be readily drained to a depth of 30 to 40 fms. below the present drainage level by continuing the Ystumtuen deep adit eastward under the workings. As the two sets of mines belong to different owners,

it is doubtful, however, whether this project will be carried out, though it appears to be the obvious way of draining the area.

Output.

The returns from these mines are given under the name of Aberystwyth in the years 1848-50, 1873, 1875, 1877-82; under Nanteos in 1848-54, 1856, 1857, 1870; under Bwlchgwyn in 1880, 1887, 1891; under Nanteos and Penrhiw in 1858-62; and under Penrhiw in 1845, 1850, 1851, 1910-17. At one period, also, Penrhiw and Ystumtuen were worked together. During that period it is not possible to say how much ore was obtained from each mine, but it is probable that most of it came from the latter, and all that ore has, therefore, been included with the Ystumtuen returns.

The following is a summary of the returns under these headings :—

—	Lead- ore.	Lead.	Ratio.	Silver.	Silver. per ton of Ore.	Silver. per ton of Lead.	Blende.
	Tons.	Tons.	%	Oz.	Oz.	Oz.	Tons.
Aberystwyth -	277 $\frac{3}{4}$	199 $\frac{1}{4}$	71	120 ¹	4	5·4	285
Bwlchgwyn -	19	13 $\frac{1}{4}$	72	—	—	—	—
Nanteos -	2,261 $\frac{1}{2}$	1,628 $\frac{1}{2}$	72	—	—	—	28
Nanteos Con- sols -	1,469 $\frac{1}{2}$	1,060 $\frac{3}{4}$	72·2	1,337	2·6	3·7	249

YSTUMTUEN INCLUDING TINYFRON.

(6-in. Sheet, Card. 11 N.E., Position of Dressing Floors,
Long. 3° 52' 0", Lat. 52° 23' 15".)

This is an old mine which was at one time worked by shafts along the outcrop. At a later period an adit cross-cut (about 570 O.D.), driven northward from the Rheidol valley, met the lode at a depth of about 78 fms. from the surface and at a distance of 234 fms. from the mouth. Dressing-floors were then erected near the road and river. This adit was afterwards continued so as to communicate with the Penrhiw workings on the east. At a still later period a deep adit (about 330 O.D.) was driven as a cross-cut from a point near the dressing-floors and intersected the lode at a distance of 270 fms. from the mouth. The levels are numbered from above downwards and are at the following depths in fathoms from the surface :—No. 1, 20; No. 2, 33; No. 3, 46; No. 4, 56; No. 5, 66; No. 6, or upper adit, 78; No. 7, 92; No. 8, 104, and the deep adit, 118. In that part of the mine which lies to

¹ The amount of silver contained in the whole of the ore appearing in the returns for these mines may be estimated at 3,556 oz.

the west of the upper adit the lode in most of the levels consists of what are distinguished as the north and south parts. In the upper levels these are separated by about 6 fms., but in the lower levels the distance increases to as much as 16 fms. These masses of ore are probably related to the footwall and hanging-wall of the lode respectively. Throughout the mine, blende is the principal mineral, in association with abundant marcasite and iron-pyrite, and smaller amounts of galena. The ore-body is fairly continuous and forms a shoot about 80 fms. long, dipping steeply to the west. It coincides with the highly undulating part of the lode, and to the west of it where the outcrop pursues an even course, the lode, as far as is known, is barren of ore. About 800 yds. west of the dressing-floors the lode has been intersected by shallow cross-cuts near Tynyfron farm; the lower of these is about 380 O.D. The structure of the lode at this point is described by Smyth (p. 663). In the upper adit it is exposed at a distance of 25 fms. from the mouth, and is at least 27 ft. wide. Here, also, it has been worked in two portions, the northern part, which adjoins the footwall, has been stoped to a width of about 10 ft.; it contains a clay-seam 12 to 14 in. wide, crowded with small crystals of marcasite; the other part has been stoped for a width of about 7 ft. Even below the supposed footwall the rocks are still somewhat shattered and impregnated with narrow seams of iron-pyrite so that the actual boundary of the lode may lie still farther to the north. Also, between the hanging-wall and the mouth of the cross-cut there are several narrow fractures dipping to the south and carrying vein-quartz and seams of clay. The belt of shattered rocks is, therefore, extremely wide at this point. The adits have been continued to a considerable distance eastward, but became unproductive in that direction, and it is said that a great length of barren lode intervenes between this point and the Ystumtuen workings.

Output.

Returns from Ystumtuen were made in the years, 1875-82, 1901, 1903-12, and from Penrhiw and Ystumtuen in 1888-95.

—	Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.	Blende.	Pyrites.
	Tons.	Tons.	%	Oz.	Oz.	Oz.	Tons.	Tons.
Ystumtuen -	816	613	75	1,634 ¹	3	4	9,795	3,860
Penrhiw and Ystumtuen.	233	166½	71	1,122 ¹	4·8	6·7	581	4

¹ The amount of silver contained in the whole of the ore may be estimated at 3,572 oz.

CAEGYNON.

(6-in. Sheet, Card 11 N.E., Long. $3^{\circ} 53' 5''$, Lat. $52^{\circ} 23' 20''$.)

This mine lies in the Rheidol valley by the side of the road three-quarters of a mile below the Ystumtuen or Cwmrheidol mine. The information concerning it is derived from two plans dated 1875 and 1899, which are preserved in the Home Office. It is doubtful, however, whether these plans are reliable, particularly as regards the direction of the cardinal points. In the 1899 plan the deviation is indicated as about 10° , which is clearly an error for that date, and this uncertainty make it impossible to obtain from the plans the true strike of the two lodes that have been worked. The north lode, which is 15 to 20 fms. distant from the south, carries galena while the south lode carries mainly blende. Each lode dips in a southerly direction at 60° to 65° . They have been worked by a shaft which appears to have been sunk between them; according to the plan the inclination of the shaft is about 50° , but for some distance below the surface its inclination can be seen to be about 70° . If the plan approximately represents the workings, the lodes were reached by cross-cuts to the north and to the south from the shaft. The lode west of the shaft strikes considerably to the north of its position to the east as if it had been heaved in the neighbourhood of the shaft. The ground was drained by two adits. The shallow adit has been driven eastward from the top of the shaft and the deeper adit (about 230 O.D.) which drains the workings to a depth of about 10 fms. from the roadside. The shaft has been sunk to a depth of 70 fms. below this adit. On the north lode the ore lies mainly to the west of the shaft and forms a nearly vertical shoot; the south or blende lode does not appear to have been worked to any great extent. One of these lodes is exposed near the mouth of the shallow adit; it consists of a shattered belt several yards in width with numerous strong fractures, most of which carry either blende or blende and galena and some iron-pyrite. The waste-heaps from the workings also contain numerous pieces of blende in association with marcasite. The lode closely resembles the Castell lode at Ystumtuen. So far as can be judged from the limited exposures the strike is, however, somewhat to the north of west, whereas between this and Tynyfron it pursues a normal direction. It is probable, therefore, that this mine is situated on one of the characteristic swerves which, as near Penrhiw and other places, carries the lode to the north of its normal course. This consideration has a bearing upon the workings which lie nearly on its strike about a quarter of a mile distant south of the Rheidol valley where numerous lodes have been worked. All of them dip to the north and no representative of the great southerly-dipping Castell lode has been found. The conditions at Caegynon suggest that this lode may occur much farther to the north than any of the workings

on the other side of the river, and it may, for that reason, have escaped detection.

Output.

Returns for this mine are available in the following years :—
1853–56, 1858, 1859, 1871, 1872, 1874, 1875.

Lead-ore.	Lead.	Ratio.	Blende.
Tons. 371½	Tons. 277¾	% 74	Tons. 717

RHEIDOL UNITED.

(6-in. Sheet, Card. 11 N.E. and N.W., Long. 3° 53' 45",
Lat. 52° 22' 15".)

The mines grouped together under the name of Rheidol United comprise at least five sets of workings on four distinct lodes. They are situated on the south side of the Rheidol valley a little above Rheidol Falls station, and nearly due west from Caegynon.

The lodes from north to south are as follows :—

1. Gwaithgoch, ranging east-and-west and dipping to the north at 70° to 75°. It is exposed in the side of the railway and in an old shaft on the slope a few yards above.

2. Nantglas, which has the same direction and dip, and lies about 60 yds. to the south. It has been traced from near the railway with a few interruptions for over three-quarters of a mile in a westerly direction, and has been extensively worked.

3. Rhiwrugos, exposed near the ravine which is crossed by the railway half a mile above Rheidol Falls station. It strikes west-south-west and dips to the north at about 80°. Its outcrop is indicated by extensive open-cut workings 250 yds. south of the Nantglas lode.

4. Alltddu, which strikes about S. 30° W. and apparently dips to the south at 75°. This is the least important lode, but the only one that has been discovered on that side of the river with a southerly dip. Although the workings on these lodes are in the main distinct they are in places connected by cross cuts. The workings formerly known as the Nantglas mine were carried on from two adit cross-cuts driven southward into the lode, which was stoped from them up to the surface. The upper or Nantglas uchaf adit (about 730 O.D.) is referred to in the plan preserved in the Home Office as the 10-fm. cross-cut; the lower,

Nantglas isaf, or deep adit, appears to be about 380 O.D. Another cross-cut has been driven southward from one of the lower levels of the Gwaithgoch mine, so as to intersect the Nantglas lode at a deeper point than the deep adit. In the Nantglas ravine, about 60 yds. south of the upper adit, the lode is intersected by a fault dipping north-westward, and is apparently displaced through several yards. A fault having a similar dip, and nearly on the same strike, intersects the Gwaithgoch lode near the railway. It would appear from the plan that the Nantglas lode was not productive farther east. The 20-fm. level has been driven east of the fault on an erratic course, but apparently without success; the 30-fm. level has not been driven beyond it. The main workings lie, therefore, to the west, and the lode was evidently more productive in the upper than in the lower levels. From a report made in 1858 it appears that at the deep adit it was 20 to 26 ft. wide, and contained small strings of lead-ore associated with some blende and spar. It was much split-up, the ground was hard and the amount of ore was not sufficient to pay for working. The cross-cut from Gwaithgoch, which subsequently met the lode at a deeper level, did not find payable ore, and no workings have been carried out from it. So far as can be judged from the plans, the ore-body, which had a length of 60 to 80 fms. near the surface, contracted rapidly downwards towards the deep adit or 63-fm. level.

The Gwaithgoch mine adjoins Nantglas on the north-east. The lode has been worked from two cross-cuts; the upper (about 320 O.D.) has been driven southward through the lode, and has been continued as a cross-cut for nearly 120 fms. to intersect the Rhiwrugos lode. The deep adit cross-cut or 52-fm. level is about 250 O.D. Each level is about 35 fms. in length, and their relative positions indicate that the ore formed a shoot dipping to the west, possibly being terminated in that direction by the fault previously mentioned.

The Rhiwrugos lode has been attacked at two points. A cross-cut or upper adit (about 480 O.D.) has been driven north-north-west from the ravine about 60 yds. west of the railway to intersect the lode, and has been extended on it for about 100 fms. to the west. Below this cross-cut a winze was sunk 10 fms., and a 10-fm. level has been driven westward for 60 fms.; from this level a connection was established with the adit cross-cut from Gwaithgoch, which appears to be about 16 fms. deeper. These workings were mainly for lead-ore, but a report made in 1858 states that the lode varied from 3 to 7 ft. in width, and carried a much greater proportion of blende than of galena. In recent years the adit has been re-opened in order to extract the blende that had been left standing in various parts of the mine. In the report referred to, the lode in the adit was estimated to contain about 2 tons of blende per fathom, and in the 10-fm. level from 2 to 3½ tons, whereas its content of lead-ore seems to have been

only a few cwt. per fathom. The present workings are known as the Erwtomau mine. About 300 yds. east of Erwtomau a deep adit (about 200 O.D.) has been driven westward from the level of the River Rheidol on the lode for 90 fms., and an engine-shaft has been sunk to a depth of 12 fms. below it, but little further work appears to have been done.

The workings on the Alltddu lode consists of two adits and a shaft; the deep adit enters at the foot of the slope near the river, and has been driven westward on the lode for about 120 fms.

To the west of the Nantglas workings a long adit, known as the Foxpath cross-cut, has been made to the Nantglas lode, but nothing is known about the workings from it. Still farther west lie the so-called Pantmawr or Imperial workings, and the Geufron or West Imperial, which are described elsewhere.

In view of the fact that these northerly-dipping lodes are almost on the line of strike of the great southerly-dipping Castell lode between Ystumtuen and Caegynon, it is remarkable that this lode has not been met in any of the cross-cuts west of the river. It has been suggested (p.99) that at Caegynon it is deflected to the north of its normal course and might, therefore, enter the opposite slope of the Rheidol valley to the north of any of the existing cross-cuts. From the strike and dip of the lodes worked in the Rheidol United mines, it is difficult to resist the impression, that the Castell lode passes to the north of them and that these are complementary to, and dip towards, it, for the strikes of the Nantglas, Rhiwrugos, and Alltddu lodes converge approximately towards Caegynon. If this be so, the east-and-west strike of the Nantglas lode, which is the principal fracture, suggests that the continuation of the Castell lode may have the same strike. There is, in fact, on the slope of the Rheidol valley, about 150 yds. to the north of Nantglas, a marked depression which may possibly indicate the outcrop of this lode. On the same line of strike is the exceedingly straight valley of Nantyraber which leads towards Aberffrwd. Again, near Aberffrwd and approximately on the same line we meet with a southerly-dipping lode which is described on p. 130. and two or three hundred yds. to the south there is a parallel lode which dips in the same direction. Not improbably these are the split-up westerly continuation of the Castell lode, nearly 2 miles to the west of the point where it was last proved.

Output.

For the sake of clearness the returns are indicated, as far as possible, under the individual headings. For Rheidol United lead-ore was returned in 1855-61, 1865-68, 1876, 1877, 1882-89; for Penclayen in 1853; for Foxpath in 1853-55, the greatest amount being 62 tons in 1855; for Erwtomau in 1915 and 1916, the greatest amount being 6 tons in 1916; for Gothic in 1865,

1867 and 1868, the greatest amount being 17 tons each in 1867 and 1868.

—	Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.	Blende.
	Tons.	Tons.	%	Oz.	Oz.	Oz.	Tons.
Rheidol United	584	395	67	500 ¹	2·8	4·3	4,515
Penclayen -	148	111	75	—	—	—	—
Foxpath -	139	97	69·7	—	—	—	46!
Erwtomau -	11½	8¼	71·8	—	—	—	383
Gothic -	41	33	80	—	—	—	—

NANTYCREIAU.

(6-in. Sheet, Card. 8 S.W., Long. 3° 46' 45", Lat. 52° 24' 23".)

This mine is situated on a tributary of the Myherin stream which enters the Rheidol at Devil's Bridge. It is connected with Devil's Bridge station by about 3 miles of mountain road, which joins the road from Ponterwyd to Devil's Bridge about 2 miles north of the latter place.

It was described by Lewis Morris in 1751 as "an ancient drowned lead mine-work of about 50 yds. long . . . where is a small rib of ore for thirty or forty yards in length in the bottom of the brook eastward and another (supposed the same vein) westward."

In 1747 it was opened by Lewis Morris for the Crown, but together with the Bwlchgwyn, Esgairmwyn, and other mines, was the subject of a dispute which lasted for many years between Mr. Powell of Nanteos and the Crown; in consequence their working was neglected.

Meyrick (p. cxxxix.) states that the mine produced "black jack, quartz, and about one-fifteenth part lead-ore. The fourth is black jack and the rest quartz." It was then, and is now, in the Crown's grant, and from the above description blende greatly predominates over galena.

The lode strikes approximately west-south-west and dips to the north at 65° to 70°; it is exposed in the floor and banks of a steep ravine, which below the mine is encumbered for a great distance by old dumps containing much blende. Similar material is abundant also all the way to Nant Myherin, and, having regard to the amount of blende thus washed away, the recorded output of that mineral gives little indication of the productiveness of the lode.

The country-rocks are slaty mudstones which lie at least 2,000 ft. above the base of the Frongoch formation, and therefore overlie the main mineral-bearing rocks of the country.

¹ The amount of silver contained in the whole of the ore may be estimated at 1,669 oz.

Another lode lies some distance to the south, but has been little worked.

The plan and section show four adits driven eastward and one westward from the ravine. No. 1 or the deep adit, is about 1,230 ft. above O.D. and about 190 fms. in length. No. 2 is about 11 fms., No. 3 about 25 fms., and No. 4 about 33 fms., above the deep adit. These have all been driven beyond the main ore-body, which had a length of about 55 to 60 fms. About 144 fms. east of the deep adit-mouth a pumping-shaft has been sunk below that level, and a drawing-shaft a little farther west; these do not communicate with the surface and their depth is not known. It is said that comparatively little work has been done below the drainage-level, but the ground between the deep adit and the surface has probably been exhausted. West of the ravine the western adit has been extended about 50 fms., and a shaft has been sunk close to the mouth near a bunch of ore 10-15 fms. long; this ore appears to have been left in the sole of the level.

West Nantycreiau.—On the slope half a mile west of Nantycreiau two cross-cuts have reached a lode dipping to the north at about 75°, and good specimens of blende-rock lie on the dumps; another cross-cut has been driven towards these workings from a point about 300 yds. to the north-west. The line of strike of this lode passes to the south of Nantycreiau, but a small deviation would carry it into that mine.

There are good facilities for working Nantycreiau by water-power, as there are three storage-lakes on the plateau above the mine, with a total area of about 20 acres and draining an area of between 500 and 600 acres. The surface of the water stands between 1,700 and 1,750 ft. above O.D., and would yield for a considerable part of the year between 200 and 300 electrical horse-power, either in the Nantycreiau valley (about 1,200 O.D.) or in the Myherin valley (about 1,150 O.D.).

The difficult approach to the mine from the main road militates, however, against its development.

Output.

Returns of lead-ore were made for the years 1845-48, 1855-60, 1863, 1864, 1881-86, 1888-90, 1893, 1895.

Lead ore.	Lead.	Ratio.	Silver. ¹	Silver per ton of Ore.	Silver per ton of Metal.
Tons. 905½	Tons. 632½	% 69·9	Oz. 138	Oz. 5	Oz. 7·2

¹ Silver was only returned between the years 1885 and 1895 when only 27½ tons of lead-ore were produced. The amount of silver equivalent to the total ore may be estimated at 4,500 oz.

Blende was returned in the years 1854-65, 1880, 1882-85, 1887-95. There is no return for 1881, although 19 tons of lead-ore were sold in that year. Total, 6,057 tons.

FRONGOCH.

(6-in. Sheet, Card. 11 S.E., Long. $3^{\circ} 52' 45''$, Lat. $52^{\circ} 21' 5''$.)

This mine is about 2 miles S.S.W. of Devil's Bridge and $1\frac{1}{2}$ miles N.W. of Pontrhydygroes. The nearest stations are Devil's Bridge about $2\frac{3}{4}$ miles by road, and Crosswood (Great Western Railway) about $4\frac{1}{2}$ miles by road.

It is one of the group of mines on the property of the Earl of Lisburne, and Meyrick records that it ("Bron-y-Goch") was discovered about 1798 by J. Probert of Shrewsbury. It yielded one-sixth lead-ore, one-eighth blende, and the rest quartz. About three years later Probert discovered a mine called Llwynwnwch, immediately east of Frongoch, and this yielded "one-third black jack, one-sixth lead-ore, and the rest quartz." In the year 1806 the lead-ores from these mines sold for 18*l.* per ton and the blende for 4*l.* 10*s.*

The old Frongoch and Llwynwnwch mines, now known as Frongoch, were taken over by Messrs. Taylor & Sons in 1834, at which time the deepest point in the workings was about 34 fms. below the surface, and only the 14-fm. and 24-fm. levels had been driven to any extent. The output from all the Lisburne mines at that time was under 40 tons per month; in the first year under that company it rose to 100 tons per month. Subsequently, another mine, called West Frongoch or Wemyss mine, lying on the same lode to the west, but belonging to another landowner, was developed in connection with Frongoch, though separate returns were made owing to the necessity of paying two sets of royalties. The workings were developed from the principal shafts which, taken in order from west to east, were Engine-shaft (117 fms.), Pryse's shaft (105 fms.), and Taylor's shaft (142 fms.). The mine was drained by an adit driven eastward from the side of the road in the Cwmnewydion valley through the West Frongoch property, to connect with the 24-fm. level.

Levels were driven at 34, 44, 56, 66, 78, 90, 105, 117, 130 and 142 fms. About 1876 a new perpendicular shaft (Vaughan's) was commenced south of Taylor's shaft, which was intended to intersect the lode at the 90-fm. level, but in 1878 Messrs. Taylor sold the mine and plant to the Earl of Lisburne. It was then taken over by Mr. John Kitto, who proceeded to break down the sides of the lode in order to extract the blende which had been left standing throughout most of the mine. In one year the output of blende was 2,850 tons or half as much again as the highest output of lead-ore.

It does not appear that the levels below the 90-fm. have been worked since 1878. After Mr. Kitto relinquished the mine it was taken over by a Belgian Company, but little was done in developing the workings; since 1903 it has been idle.

Including the adit the mine has a total length of about 800 fms., but the main productive part lay near Taylor's shaft, and for about 120 fms. east and west thereof. In that region the galena-bearing part of the lode was from 2 to 4 fms. wide, the ore being found as a rule in two more or less distinct branches, referred to as the north and the south part of the lode, with usually a barren piece of ground intervening. It appears that the blende occurred mainly to one side of the galena, and was associated as a rule with the footwall. Along the outcrop of the lode, in the opencast near the east end of the mine, pale blende may be seen at present forming a solid rib 8 to 15 ins. wide in a hard quartzitic rock, close to the footwall of the lode; similar conditions occur in the mouth of the deep adit, where the blende forms strings from $\frac{1}{2}$ to $2\frac{1}{2}$ ins., and of a total width of about 4 ins.

At the east end attempts to prove a productive lode in the adit north-east of Llwynwnwch farm did not meet with success. Cross-cuts were driven north and south; a lode was cut in each and driven upon for some distance, but proved very poor. The most easterly point at which galena was worked lay almost due north of the farm.

The Form of the Lead-Ore Body.—There appears to be little doubt that the explorations in the deeper parts of this mine proved the body of lead-ore to taper somewhat rapidly in depth, so that the bunches which were almost continuous for nearly 250 fms. in the 24-fm. and 44-fm. levels were only about 100 fms. in the 105- and about 70-fms. in the 130-fm. level. Outside this main body small bunches of ore were found between the surface and the 56-fm. level, from 60 to 200 fms. west of the Engine-shaft, but very little, if any, was found in the 66-fm. driven underneath those bunches.

There does not seem, however, to have been any appreciable diminution in the size of the lode or its local content of ore even at the bottom of the mine. Thus, at Taylor's shaft in the 142-fm. level, the south branch was about 6 ft. wide, and carried from $\frac{1}{2}$ to 1 ton of ore per fathom; the north branch, which was about $3\frac{1}{2}$ fms. distant, yielded $2\frac{1}{2}$ tons per fathom; the lode at this point had, therefore, a width of probably about 30–33 ft. if the intervening barren portion be included. In the 130-fm. level the south branch yielded in places over 1 ton, and the north branch up to $3\frac{1}{2}$ tons per fathom, and a stope over the 130-fm. level yielded for a length of 10 fms., 5 tons per fathom. The usual yield in the upper parts of the mine was from 1–3 tons per fathom of driving, but as many of the levels were driven on the north part as well as the south part, the yield for the whole width of the lode reached, perhaps, 2 to 4 tons per fathom. In addition to the lead-ore the lode was rich in blende, which appears to have lain mainly on the north side of the lode towards the footwall and to have maintained itself on the whole distinct from the galena.

Between 1859 and 1876, when the mine was worked for lead-ore only, 440 tons of blende were sold, while the average annual output of lead-ore was 1,328 tons. It was probably mixed with the galena or attached to the sides of that ore-body. The ratio of galena to blende thus indicated is about 60 to 1. It is probable, however, that owing to the low price of blende no particular effort was made to recover it, and a large amount must have passed into the refuse-heaps. When the succeeding company began to strip the walls of the lode, an average output of 1,962 tons of blende was maintained between 1879 and 1903, while the galena obtained in breaking down unworked pillars, with that which was mixed with the blende, amounted to 282 tons on the average, or about one-seventh of the blende output. Since 1859 about 30,000 tons of galena and about 50,000 tons of blende have been returned from the mine, so that on the average galena and blende have been recovered in the proportions respectively of 38 and 62 per cent. of the total ore, or approximately in the ratio of three to five. If the original content of ore were taken into account the proportion of blende would be higher, for the reasons that in the earlier years succeeding 1859 much of the blende-bearing rock raised to the surface was not dressed, but sent direct to the refuse-heaps or hillocks, and the proportion of loss in dressing blende is higher than in dressing galena. It is not unlikely that the lode contained originally about 2 tons of blende for every ton of galena.

The causes which led to the abandonment of the mine are worthy of examination. There is no known geological cause to account for an impoverishment in depth, for the base of the Frongoch formation is probably about 3,000 ft. below the surface, and there is, therefore, no reason to suspect the influence of the Gwestyn shales. When Messrs. Taylor gave over the mine in 1879 it was returning over 1,000 tons of galena per annum, but the expense of keeping the bottom levels dry and of raising the ore was greater than the value of the produce. In the three years 1875-8, 3,205 tons of ore were sold for 44,857*l.*, which, after deducting royalties made a loss to the company of 679*l.* The quantity of water appears to have been considerable, and the lode from about the 90-fm. level downwards is described as having been extremely hard, which added to the cost of breaking ground. In addition, owing to frosts in winter and droughts in summer, water-wheels could not be relied on for pumping, and a steam-engine was required, necessitating transport of coal. The distance of the mine from a railway also militated against its success. There is little doubt that there are reserves of galena and probably even larger reserves of blende below the 90-fm. level, but the expense of re-opening from the surface would probably be greater than the value of the ore, even with an enhanced price. It is of interest, therefore, to examine an alternative scheme which has been suggested. About a mile and a quarter south of the western end of the Frongoch workings an

adit (Grogwynion deep adit) has been driven northwards from the Ystwyth valley for about 400 fms.; the mouth of the adit is about 310 ft. above Ordnance Datum. The mouth of the Frongoch adit or 24-fm. level is about 615 ft. above Ordnance Datum. Allowing for the rise in both levels the Grogwynion deep adit would drain the mine about 52 fms. deeper than the Frongoch adit; which would correspond to a level nominally of about 76 fms. in the mine. Again, Taylor's shaft is approximately about 810 ft. above Ordnance Datum, so that the deep adit would be about 80 fms. below the surface in the neighbourhood of that shaft. From the longitudinal section of the mine this point appears to be about midway between the 66 and 78-fm. levels. The nearest point to the present end of the deep adit where workings of that depth exist is 20 fms. south of the engine-shaft, which would necessitate driving the adit a further distance of 940 fms. If this scheme is carried through, dressing-floors will probably be established in the Ystwyth valley at a distance of less than 4 miles by road from Crosswood station. At present dressing-plant is being installed at the Gwaithgoch mine about half a mile west of the mouth of the Grogwynion deep adit for the purpose in part of treating the enormous refuse-heaps at Frongoch, and an aerial ropeway is being installed for the carriage of the stuff from this mine to the dressing floors, a distance of about $1\frac{3}{4}$ miles.

Output.

Frongoch produced lead-ore without a break from 1834 till 1903, since when it has been idle. The output is obtained from figures or estimates in Messrs. Taylor's Annual reports or from the Mineral Statistics. Between 1834 and 1844 about 5,426 tons were sold. The approximate output between 1845 and 1903 was :—

Lead-ore.	Lead.	Ratio.	Silver. ¹	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 50,669	Tons. 38,071	% 75·1	Oz. 19,014	Oz. 2·5	Oz. 3·3

Blende was returned in the Mineral Statistics for the years 1854–61, 1863, 1864, 1871, 1879–1903. The amounts up to 1877 compare closely with those recorded by Messrs. Taylor. Total output since 1854, 50,856 tons.

¹ Only returned in 1860, 1872, 1873, 1875, 1878–81, 1896, 1901, 1903. Probable amount of silver in lead-ore obtained since 1845, about 128,000 ozs.

WEST FRONGOCH AND WEMYSS.

Although on a different property these two mines are on the westerly continuation of the lodes worked at Frongoch, and the adit for that mine drains through Wemyss mine. The two mines have generally been worked together with Frongoch. Although there is some confusion in the names, the workings of the Wemyss mine lie east of the road from Pontrhydygroes through Cwmnewydion, while the name West Frongoch was applied by Messrs. Taylor about 1845 to some workings near the junction of the two streams south of Cwmnewydion uchaf. West Frongoch is 500 yds. west of the adit-mouth of the Wemyss mine, but there is no connection between the workings.

The mouth of the Frongoch adit is about 50 yds. east of the road and is approximately on the footwall of the main lode, along which the adit was driven eastward for about 150 fms.; at this point it turns sharply to the north-east for about 25 fms., before turning eastward again on a lode. The workings of Frongoch proved, however, that the lode in that part of the adit was to the north of the main lode on which the 24-fm. level had been driven westward from the engine-shaft; and a cross-cut of about 26 fms. was necessary to establish a connection between the two levels, which was made at the shaft called the Boundary shaft, situated near the junction of the two properties. From this shaft the adit, 44-, 56-, and 66-fm. levels were subsequently driven to varying distances westward; but only short bunches of ore were found.

The north lode, on which the adit was partly driven, outcrops on the surface about 20 fms. north of the Boundary shaft, and is a narrow joint-lode with a very small underlie to the north; nearly 50 fms. westward a shaft (Glanville's shaft) has been sunk to a shallow adit driven into this lode from the south.

About midway between the Boundary shaft and the mouth of the adit a lode is exposed in a collapsed stope or shaft which is connected with a shallow adit. It is 4 to 5 ft. wide, with a slight underlie to the north, and ranges directly for the lode seen in Glanville's shaft and along its outcrop eastward. There is little doubt from its direction, underlie, and other characters that it is the "north lode" of Frongoch. North of it, however, are extensive remains of shallow workings which are almost continuous down to the mouth of the adit, where the lode has a considerable south underlie and other features characteristic of the main lode. It seems clear that the so-called north lode has crossed the main lode at a point about 110 fathoms west of the Boundary shaft and near New or Ball's shaft which was sunk to the 66-fm. level. There is no evidence that this "north" lode was worked west of the western shallow adit, and the stopes above the main adit from that point to

the mouth shown in the longitudinal section of the mine as being on the north lode were presumably on the main lode.

West Frongoch.—Some time before 1854 a shallow adit driven eastward from the stream south of Cwmnewyddion uchaf cut two lodes about 3 fms. apart. The south or main lode was opened for 40 fms. and the north lode for 25 fms. by Messrs. Taylor in 1854, and both were found to contain "gossan, loose spar and clay as well as some fine rich and large lumps of lead-ore." Subsequently, a shaft was sunk a few yards south of the adit and cut one of the lodes at 16 fms. below the surface, but in driving eastward upon it a yield of only about half a ton per fathom was obtained. It is not known whether the expressed intention of testing the lode at greater depth was carried out; there is no further mention of this trial in Messrs. Taylor's reports. The lode revealed in the mouth of the adit is highly silicified and cherty in appearance, with some pale blende similar to that found at the mouth of the Frongoch adit and at the east end of that mine. A width of 10 ft. is exposed, but the workings upon it to the east are considerably wider than this. The lode dips south at about 70°, and there can be little doubt that it is the westerly continuation of the whole or part of the Frongoch main lode, with which its characters are in close agreement.

Output.

Returns are given for the years 1861, 1863-65, 1867-73, 1882-92, 1894, 1898, 1899.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Metal.
Tons.	Tons.	%	Oz.	Oz.	Oz.
1,274	921 $\frac{1}{4}$	72·3	1,159 ¹	3·3	4·6

Blende was returned in the years 1882-92, 1894, 1897-99. Total, 1,975 tons. The proportion of blende to galena is, therefore, nearly the same as at Frongoch.

RED ROCK OR GRAIGGOCH.

(6-in. Sheet, Card 11 S.W., Long. 3° 54' 10", Lat. 3° 20' 55".)

This is a mine on the Lisburne property, situated on the south slope of Cwmnewyddion. About 1840 Messrs. Taylor commenced operations by driving two adits westward into the hill, but it appears that there had been some work done near

¹ The probable equivalent of silver in the ore is about 4,200 oz.

the outcrop of the lode prior to that time, for on the refuse-heaps may be seen several flattish grit-slabs with concave worn surfaces which had been used in conjunction with other stones to break down the ore by hand ("bucking"). The mouth of the upper adit, later called the middle adit, (about 670 O.D.) was probably a few yards west of the pumping-shaft and was driven on the main lode. The mouth of the lower or deep adit was about 150 yds. to the east, and about 15 or 16 fms. deeper (about 580 O.D.); it is said to be driven on a lode which joins the main lode westward. The upper adit was driven about 150 and the lower about 210 fms. As some good ore was found in them a shaft was sunk on the lode to a depth of 60 fms. below the adit. Subsequently, a new or eastern shaft was sunk to a depth for a 12-fm. level. The promising appearance of the upper levels was not apparently maintained in depth where the bunches were short and the ground was hard; the yield varied, however, from three-quarters of a ton to 2 tons per fathom, the average being 1 to $1\frac{1}{2}$ tons. The best ground was found to be in the neighbourhood of the pumping- or engine-shaft. At the eastern shaft the lode to the east of it was found to be large but broken up by soft joints; little ore was obtained also west of the shaft. The total output during Messrs. Taylor's tenure of the mine appears to have been about 2,300 tons, obtained in 23 years' working, or an average of 100 tons per annum.

The mine was subsequently worked by various companies from 1877-82 (output 775 tons) and 1886-9 (output 170 tons of galena and 25 tons blende). Nothing is known of the extent of the later workings, as no plan has been available.

Output.

The amount of lead-ore produced can be obtained from the Mineral Statistics or from Messrs. Taylor's reports for the years 1846-55, 1869-75, 1877-82, 1886-9 :—

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Metal.
Tons.	Tons.	%	Oz.	Oz.	Oz.
3,282	2,438	74·3	815 ¹	3·67	5

Blende was sold in 1888 and 1889. Total, 25 tons.

¹ Silver was only returned in 1875 and 1877. The probable amount of silver contained in the whole of the ore is 12,000 oz.

GROGWYNION.

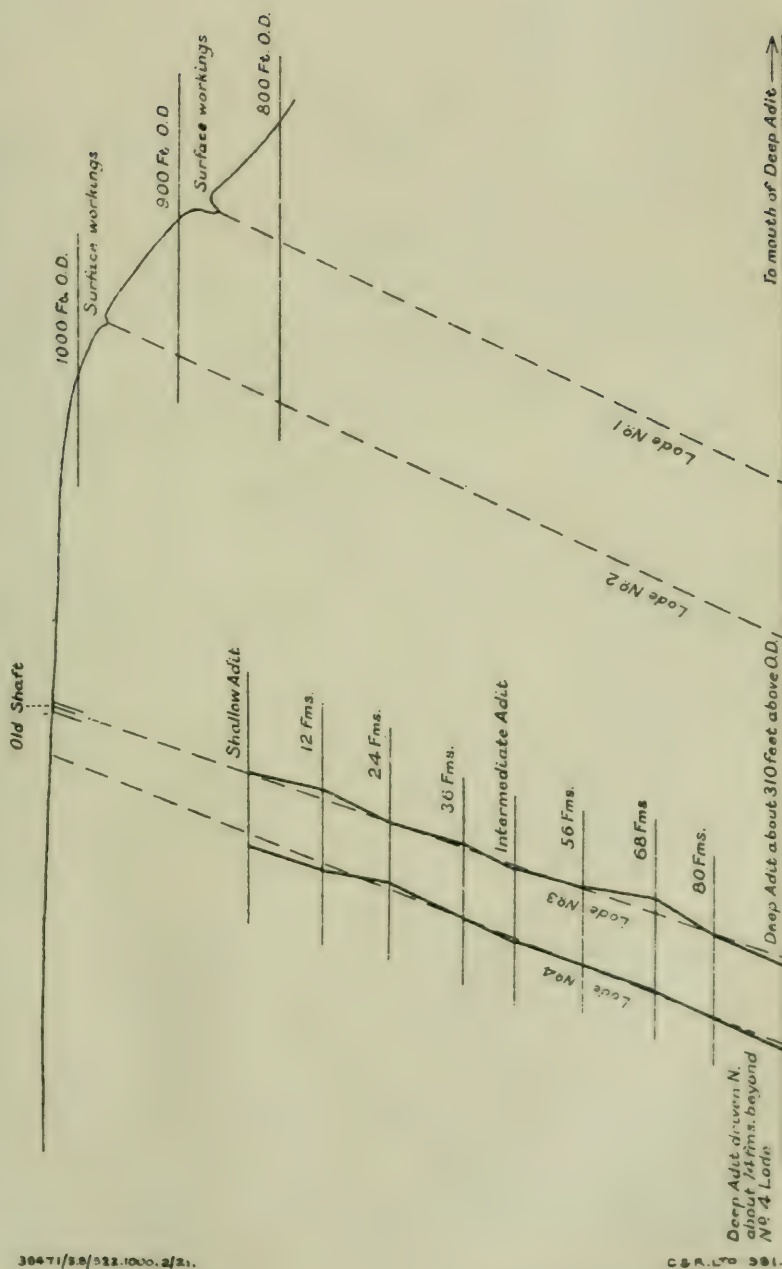
(6-in. Sheet, Card. 16 N.E., Long. $3^{\circ} 53' 10''$, Lat. $52^{\circ} 19' 55''$.)

This mine lies on the north slope of the Ystwyth valley about $1\frac{1}{2}$ miles west of Pontrhydygroes. Four distinct lodes have been intersected in some of the levels, and are named in order from south to north, Nos. 1, 2, 3 and 4 (Pl. XVI). Considerable workings have been carried on near the surface on the No. 1 lode, but the main explorations in depth have been confined to No. 3 and No. 4.

Most of the earlier workings were carried on from an old shaft at an altitude of about 1,000 ft., and a cross-cut called the intermediate adit (about 574 O.D.). At a later period a deep adit (about 310 O.D.) was driven in from the side of the valley south of the older workings. All the lodes were intersected in turn, and the adit was extended for a distance of 70 to 80 fms. north of the No. 4 lode. The total distance from the mouth to the forebreast is about 383 fms. A new shaft was sunk from the surface about 100 fms. east of the old shaft, and continued to a depth of 36 fms. below the deep adit. The levels in the mine are reckoned from a shallow adit (about 835 O.D.) and are as follows.—12, 24 and 36 fms., intermediate adit, 56, 68 and 80 fms., deep adit or 110 fms., and 12, 24 and 36 fms. below the latter.

Longitudinal sections of the mine indicate that most of the ore occurred above the deep adit, and had been largely removed before that was driven. The total length of the ore-body is about 190 fathoms. It appears to have been sharply terminated, both laterally and in depth. The extension of the deep adit for 100 fms. eastward of the limit of the ore-body proved the No. 3 lode to be barren and highly disturbed by slides and cross-courses. Similarly, the No. 4 lode was interrupted eastward by a slide or cross-course, and both lodes at the bottom of the mine were in a disturbed and scattered condition. As seen at the surface, the lodes are comparatively narrow fissures of the nature of somewhat wide joints, and are filled with brecciated mudstone and finely-crystallized quartz; lodes of this type are found by experience to be of local occurrence and have not, as a rule, great lateral extent. Probably the same holds as regards the vertical distribution of the ore.

West of Grogwynion the same lode-belt traverses Gwaithgoch mine, where probably both the No. 1 and No. 3 lodes can be recognised, but they tend to approach one another and to unite within the workings. Exploration by trenches west of Gwaithgoch has, according to Messrs. Taylor, revealed the extension of these lodes in that direction, but no ore has been found. Again, towards the east, between Grogwynion and the valley of the River Cell, various attempts have been made to discover them in a profitable condition.



30471/58/522.1000.2/21.

C.S.A. 170 581.

TRANSVERSE SECTION OF LODES AT GROOWYNION.

Output.

The output can be obtained for the years 1850-53, 1855, 1857, 1858, 1860, 1864, 1865, 1870-89 :—

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 8,874½	Tons. 7,053	% 79·4	Oz. 29,322½	Oz. 5·5	Oz. 6·9

CWMYSTWYTH.

(6-in. Sheet, Card. 12 N.E., Long. 3° 50' 0", Lat. 52° 21' 20".)

This mine lies on the north side of the River Ystwyth, about 5 miles by road from Devil's Bridge Station. Apart from the evidence of what are probably prehistoric workings, it is clear that the mine has been exploited more or less continuously for several centuries.

The workings fall naturally into three areas: (1) the western or Pugh's workings; (2) the central or Kingside workings; and (3) the eastern or Copper Hill workings.

(1) Pugh's workings lie under the slope to the west of the mine-buildings, and were reached from Pugh's shaft, the adits known as Gill's higher level, Gill's lower level and that leading to Pugh's shaft. From the shaft 15-, 30-, 40- and 54-fm. levels were driven to intersect the principal lodes. Towards the western part of the workings a 36-fm. level was entered by an incline from the 30-fm. level and driven for some distance. On the upper part of the slope between Gill's higher level and the outcrop there are three other adits, viz., Middle level, Raw's level and 12 fms. above Raw's. The Middle level is about 12 fms. and Raw's about 24 fms. above Gill's higher level (see Fig. 4).

In this part of the mine two important lodes were worked, which were called the Comet and the Main; they dip to the south, the Comet being north of the Main lode. In the northern part of the workings Mitchell's lode, which has a dip to the north, was worked from Gill's higher and Gill's lower, the 15- and the 30-fm. levels.

In addition various branches of the Comet and the Main and one or two other unimportant lodes have been worked. One of these, known as Gill's lode, which was cut in Gill's lower level, was believed to be the one met in the Kingside workings and Bonsall's level. That lode is, however, the easterly continuation of Mitchell's lode, which was first intersected in Mitchell's level.

¹ The total amount of silver may be estimated at 48,490 oz.

Character of the Lodes.—The Comet is a wide lode of open structure, with a clearly-marked footwall. It consists of a mixture of galena and blende, with occasionally a considerable amount of iron-pyrite mixed with the other ores, but the

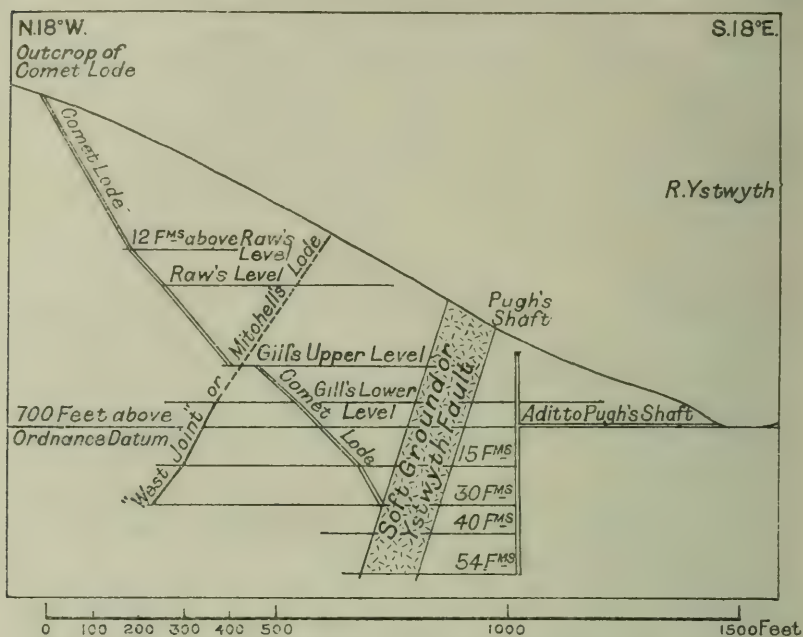


FIG. 4.—TRANSVERSE SECTION OF LODES AND YSTWYTH FAULT AT CWMYSTWYTH.

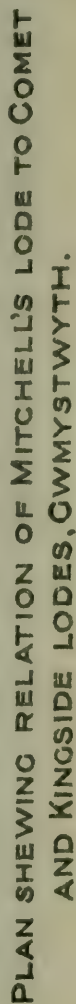
branches which spring from it generally carry galena. The gangue is mainly crystallized quartz (occasionally calcite), together with fragments of the country-rock.

The ore-bodies throughout most of this part of the mine east of the intersection with Mitchell's lode, were practically continuous and were often from 3 to 9 ft. wide. The debris from the workings has a characteristic rusty appearance.

The Main lode is about 3 ft. wide; it carries galena with massive quartz as gangue and is not usually mixed with blende and pyrite. In the western part of the workings at and below the 15-fm. level it was found to lie flat over an area of at least 150 sq. yds., and throughout this extent was composed of 6 ft. 2 in. of solid galena. The 30-, 36 and 40-fm. levels show no sign of the flat. The lode has a fairly regular dip, but in going west its strike deviates considerably towards the north.

The 54-fm. level after passing through the "soft ground" was driven nearly parallel with, and to the north of, it, to intersect the main lode, but owing to the change of strike failed to reach it.

Mitchell's lode was first discovered in Mitchell's level; above this level the ore was mostly galena in vughs; from Mitchell's level to Gill's higher it was in ribs and from that down to the 15-fm. level it was practically all blende. At the 30-fm.



level, where it has been tested, the ore is 16 in. wide, and consists in places of solid blende and in others of 12 in. of blende and 4 in. of galena. The lode dips everywhere to the north at from 45° – 60° . It is comparatively narrow with a little quartz and occasionally contained solid blende up to 43 in. in width. Its relation to the main and Comet lodes is most clearly seen in the Kingside workings and in the ravine north of the Kingside shaft (Pl. XVII).

In the western part of Pugh's workings the Comet is affected by a disturbance which is termed the "west joint." The working-plans indicate a displacement or heave to the north on the west of the joint which suggests a downthrow to the west along this line. It is not certain, however, that the Comet lode has always been correctly identified. In Gill's higher level it was worked as a large rich lode up to the so-called "west joint"; beyond this point the level was driven for about 100 fms. on a narrow string, but the main body of ore (chiefly blende) lay 12 to 15 fms. north of the level and should probably be identified with the Comet lode. In Gill's lower level the Comet as a rich lode was worked up to the "west joint." The main body of ore on the west lay 16–18 fms. farther north.

In the 15-fm. level the Comet was intersected by Mitchell's lode and was identified also to the west at the same level, but at that point it carried no ore; its position corresponds with a displacement, on crossing the line of Mitchell's lode, of about 15 fms. In the 30-fm. level the "west joint," against which the Comet lode terminates, lies exactly on the line of dip and strike of Mitchell's lode at the 15-fm. level.

The supposed Comet lode west of the joint is about 44 fms. to the north of the intersection, but as this is only a narrow string, the main body probably lies still farther north and the displacement on crossing Mitchell's lode may be as much as 56 fms. This greater displacement as compared with the upper levels may be accounted for by a local change of strike in the lodes. There is little doubt that the so-called "west joint" of this part of the mine is no other than the intersection at different levels of Mitchell's lode with the Comet.

Mitchell's lode also cuts the Main lode in the 30-, 36- and 40-fm. levels, where it was exceedingly rich and, though worked for lead, it contained a much larger amount of blende, which, at that time, was not recovered.

(2) The central or Kingside workings are based on the Kingside Engine-shaft and the adit (about 750 O.D.) which drains it. Farther east the Level fawr or Bonsall's level (about 820 O.D.), after intersecting the lodes, has been driven northward for a further distance of about 150 fms. Between this level and Nant yr Onen there are other levels such as Top adit, Cross Road level, Jackilas, &c.; Taylor's shaft also was sunk with the intention of working the deeper levels of the Kingside section.

The Lodes.—The names given to the lodes have varied at different periods. The principal lode is called the Kingside, and another is distinguished as the Belshazzar or Copper lode; both these underlie south. Other lodes are the Pumpsink which underlies to the south and the Pengeulan (Penglin) group. On the working-plans there are also distinguished certain joints or interruptions to the lode. There has been a good deal of confusion between the Kingside and the Belshazzar or Copper lode. The latter, west of Level fawr, lies some distance to the north of the Kingside, but east of that level the two approach one another and the combined lode is there known as the Kingside. Still farther east they pursue totally different courses, the Kingside being then to the north; the other lode is there identified with the Comet.

In Level fawr and the adit there is a north-dipping lode, which intersects the Kingside and Belshazzar lodes and repeats them, the effect being equivalent to a downthrow north. This lode was identified as Gill's lode, but can be shown, both from the plans and from the surface-evidence, to be the eastward continuation of Mitchell's lode. In the adit the Belshazzar was worked about 7 fms. south of "Gill's," but immediately north of that lode it was cut a second time. The Kingside was not identified in this level.

In Level fawr the position of the Kingside is not certain, but it is probably the large lode which was worked about 2 fms. south of Gill's; the Belshazzar was worked in the same level at the point where Gill's crosses it. Both lodes were cut again by the level, the Kingside about $1\frac{1}{2}$ fms. and the Belshazzar about $3\frac{1}{2}$ fms., north of Gill's.

Character of the Lodes.—The Belshazzar varies in width from 12 to 40 ft.; it carries galena and blende in large masses, but no iron-pyrite. It resembles closely in its general characters the Comet lode of the western workings. The Kingside similarly corresponds with the Main lode farther west.

When the Belshazzar and Kingside lodes approached one another, soft ground occurred in both Level fawr and the adit; to the east a very large body of ore was worked in Jeremiah's stope at and below the 15-fm. level, and from there almost up to the surface.

The Kingside shaft was sunk 35-fms. below the adit, and levels were extended at 15, 23 and 35 fms. The strike of the lode north of the shaft is a few degrees east of north. The ore-body was extraordinarily rich, but seems to have narrowed downwards. The extension of the 15-fm. level south of the shaft entered gravel in a distance of about 40 yds., and much water was met. This gravel which is of glacial origin is thus 90 ft. below the level of the Ystwyth. It probably lies on, or near the line of, the Ystwyth fault, the surface-position of which is, therefore, near the Kingside adit-mouth.

(3) On Copper Hill the Kingside lode gives off a number of branches which range in about the same direction as the main lode, supposed to be the second branch from the north. Eastward from Alderson's level this lode yielded much blende; at the point where the level was abandoned the lode was strong, yielding blende, some galena and 3 dwt. of gold per ton. Bonsall's level (not the same as the Level fawr), about 17 fms. higher than Alderson's, reached the same lode; it was not worked there, but there was a rise upwards to connect with some of the old workings on Copper Hill.

Taylor's level was an attempt to drive underneath these old workings, but there is no evidence of the Kingside lode having been cut at the end of the level. From the plans, together with the surface-indications, it appears possible that it stopped just before reaching the lode, which is nearly vertical thereabouts.

The Comet on Copper Hill is a mixture of blende, galena and copper-pyrite in a gangue of calcite, dolomite, crystallized quartz, and fragments of country-rock; it is a very wide, open lode. In parts of Taylor's level it carries fairly-rich galena with copper-pyrite in the dolomite. That level is the deepest exploration of this tract of ground, but the Comet has been driven upon for a considerable distance at a higher level, from both the King's and Queen's levels, and some rich bunches of galena were obtained from it. Farther east the Blue level intersected a lode which is approximately in the position of the Comet, but it is probable that only a south branch was cut. At the surface, a few fathoms north of the end of this level, a rich bunch of galena was worked on what is probably the main branch.

Pengeulan Lodes.—This is a group of small lodes, outcropping to the south of the principal workings and along the slope north of the road from Cwmystwyth to Rhayader. It includes from north to south: (1) the New lode or Fox's lode, a north underlier worked from Day level; (2) the Pengeulan south underlier, worked in Pengeulan shaft, &c.; and (3) Pengeulan north underlier. These lodes were richer in silver than the other lodes in the district but nothing is known at present of the old workings on them.

Output.

The output can be obtained for the years 1848–92, 1900–09, 1911–14, 1916:—

Lead-ore.	Lead.	Ratio.	Silver. ¹	Silver per ton of Ore.	Silver per ton of Lead.
Tons.	Tons.	%	Oz.	Oz.	Oz.
32,912½	24,566½	74·6	33,509	3·3	4·4

Blende, 18,913 tons.

¹ The total amount of silver may be estimated at 108,400 oz.

LOGAULAS.

(6-in. Sheet, Card. 16 N.E., Long. $3^{\circ} 50' 45''$, Lat. $52^{\circ} 19' 45''$.)

Meyrick, in 1810, writes of Log y las (Logaulas) as an old work, consisting of lead-ore and quartz, one-sixth being lead-ore. An adit (about 556 O.D.) called Level fawr was begun in 1785, but had not been completed in 1810. When a lode was subsequently cut and found to be barren the mine was abandoned; afterwards some Cornish adventurers' drove the adit forward a few feet and "cut the true lode in the midst of a vast deposit of ore which yielded rich returns for several years. This company, however, in their turn, fell into a similar error, and, losing the true lode, mistook for it a small vein on the south, dispirited with whose poverty they surrendered the mine. The present holders (Messrs. Taylor), after making an accurate survey, were satisfied that they must be too far southward, drove a 'cross-cut' towards the north and very shortly discovered, not only the lode but a rich 'bunch' of ore, parallel to which their predecessors had been toiling for many a fathom through barren rock at a distance of only a few feet."¹

Messrs. Taylor took over the mine in May 1834 and worked it successfully for about 40 years. The previous workings of Old Logaulas lay a considerable distance to the west of the point where the deep adit cut the lode; they were drained by pumping, and had reached a level about 30 fms. above the deep adit. As this adit or 60-fm. level was driven east and west, the old shafts were deepened and new shafts sunk; ultimately there were six shafts from west to east of the given depths in fathoms as follows:—Taylor's (105), Flat-rod (60), Vaughan's (120), Eddy's (130), Worsley's (90), and the Eastern shaft (44), and levels were driven at 10, 26, 36, 44, 60, 70, 90, 105, 120 and 130 fms. Owing to the great width of the lode some of the levels have been driven on two branches, which are in places 15 fms. apart.

The Ore-body and the Distribution of the Ore.—In comparison with its great horizontal extent of 600 fms., the ore-body proved to be surprisingly shallow, being limited to the depth between the surface and the 120-fm. level, and, even in the central or deepest part of the mine, there is a considerable area where it does not descend below the 90-fm. level. In general it has the appearance of a stratiform body, its base forming a gentle trough, the greatest continuous length of it being about the level of the deep adit.

The ground west of Vaughan's shaft yielded in driving about 1 ton per fm., east of that shaft the yield rose to $1\frac{1}{2}$ or 2 tons, and even in places to 3 tons per fm. Near Eddy's shaft there was a yield of $2\frac{1}{2}$ to 4 tons per fm., and again, east of Worsley's shaft, 2 to 3 tons per fathom were obtained from a large extent of workings. The lode thus proved to be one of the richest in

¹ W. W. Smyth, *Mem. Geol. Surv.*, Vol. ii., Pt. 2, p. 671.

the district, and the rapid falling off both in the extent of the productive ground and in its yield in the lower levels is the more remarkable. In the 105-fm. level there were two "runs" or ore, about 60 and 160 fms. in length, yielding from 1 to $2\frac{1}{2}$ tons per fathom. This ore hardly reached the 120-fm. level, and the lode in the 130-fm. level both at Eddy's and Vaughan's shaft was very poor. Towards the west the deterioration appears to have been gradual, short bunches of ore having been found to extend beyond the main mass. On the east, however, the productive ground is limited sharply by a line drawn from the outcrop, midway between Worsley's and the Eastern shaft, to the 105-fm. level under the former.

A few fathoms east of that line the lode was disturbed, and in both the 44- and 60-fm. levels, at about 60 fms. east of the eastern shaft, a large cross-course dipping to the west was intersected. It is not improbable that this is the continuation northward of that met in Glogfach and Glogfawr, nearly a mile to the south, which had a similar inclination. The lode and adjoining rock in the deeper parts of the workings were soft and barren, but the failure of the workings in depth is attributed by old miners to the lode having come to an end against a flat rock-floor without any break in it, and Messrs. Taylor record that at one point in the 120-fm. level, about 70 fms. E. of Vaughan's shaft, the workings "were poorer than expected, the lode having become very flat."

It is, of course, possible for the part of the lode carrying the ore to have been interrupted by a bar of rock projecting into it, or by a horizontal slide, but that the wide fracture in which the ore occurs, which can be traced horizontally for many miles and produces a displacement of the rocks of over 50 fms., should cease to exist at the shallow depth reached by these workings is inconceivable. The barrenness of the lode in the 120- and 130-fm. levels offered, however, no inducement to investigate it at greater depths. West of Taylor's shaft the lode contains a considerable amount of blende, which appears to replace the galena in that direction.

The nature and structure of the rocks adjoining the lode may have exerted some influence upon the form and position of the ore-body. On a broad view the workings lie on the eastern flank of a strong anticline, the axis of which ranges north-and-south about a mile to the west; along this anticline the Gwestyn shales outcrop over a considerable area. The nearest point to Logaulas at which these rocks occur at the surface is near the Ysbytty Ystwyth Road, about one-third of a mile west of the workings. From the outcrop they descend eastwards into a syncline, and then rise with many small undulations to the crest of an anticline which passes to the east of Worsley's shaft (*see* Pl. XVIII.). At that point they are probably within about 200 ft. of the surface in the footwall of the lode.

Practically the whole of the ore-body lies, therefore, between the crest of the anticline near Worsley's shaft and the bottom of the syncline, about a third of a mile to the west, *i.e.* it is situated on the undulating western flank of that anticline. North of the lode the Gwestyn formation is on the average about the level of the deep adit. The lode behaves as a fault with a downthrow to the south, which may be estimated at about 50 fms.; on the south side or hanging-wall of the lode these shales lie, therefore, about 110 fms. below the surface. It is highly significant that the impoverishment of the lode in depth occurred between the 105- and the 120-fm. levels, and it is difficult to resist the impression that the presence of the pyritous shales has been in some way responsible for this result.

Output.

This mine was producing lead-ore in the years 1834-75, 1877-80, 1886-91. For many of these years there are returns in the Mineral Statistics; for others the amount may be estimated from figures given by Messrs. Taylor:—

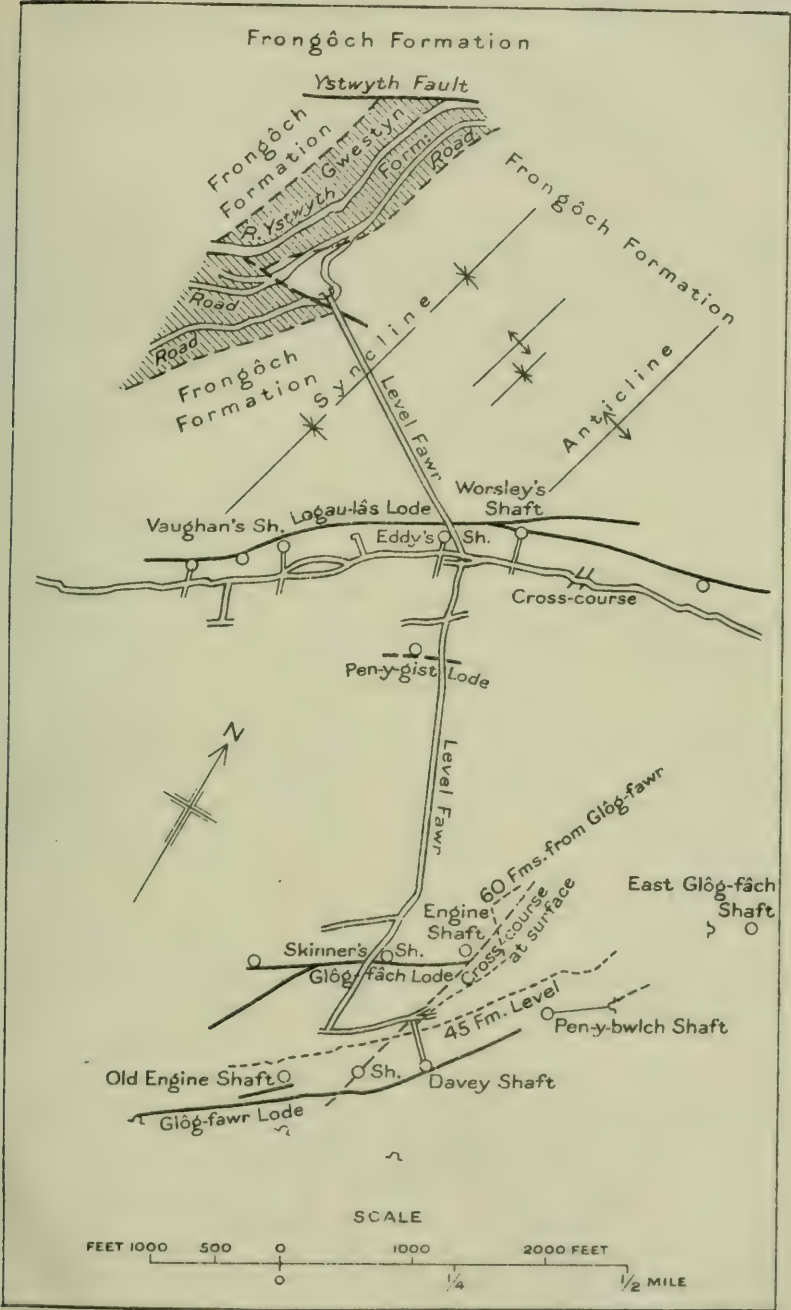
—	Lead-ore.	Lead.	Ratio.	Silver. ¹	Silver per ton of Ore.	Silver per ton of Lead.
	Tons.	Tons.	%	Oz.	Oz.	Oz.
Before 1845 -	10,340	—	—	—	—	—
Since 1845 -	28,664	19,776	69·0	19,668	3·5	4·5

GLOGFACH.

(6-in. Sheet, Card. 16 N.E., Long. 3° 50' 20", Lat. 52° 19' 20".)

This mine is one of the Lisburne group, and lies a little less than a mile E.S.E. from Ysbytty Ystwyth. It was taken over by Messrs. Taylor in 1834, but one bunch of ore had previously been worked to a depth of about 50 fms. below the surface. The chief developments were carried out between 1854 and 1880, mainly from two shafts about 64 fms. apart. The eastern or engine-shaft was sunk to the 48-fm. level, and the western or Skinner's shaft to the 130-fm. or deepest level. The levels are reckoned from the surface and were driven at 16, 26, 36, 48, 58, 73, 88, 103, 118 and 130 fms. The mine during its most productive period was drained by pumping, but about 1872 the deep adit or Level fawr was completed to the Glogfach workings and drained them to the 118-fm. level (*see* Pl. XVIII.). The ground above this level was by that time practically exhausted,

¹ As silver was returned for about 17 years only, the amount in the ore is much in excess of this figure. The total quantity since 1845 may be estimated at 94,700 oz.



56471/8.3/822.1000.2/21.

C&R LTP 381.

GEOLOGICAL MAP OF THE DISTRICT
NEAR PONTRHYD Y GROES.

but it was hoped that deeper workings would prove as productive as the upper had been. Unfortunately, this expectation was not realised; the rich lode which had been worked in the 103-fm. level fell off considerably in the 118-fm. level, and in many places the ore did not hold down more than 3 to 4 fms. below, so that the great bunch worked in the upper parts of the mine extended for a few fathoms only along the 130-fm. level. It was worked for some feet under the sole of that level, about 75 fms. west of Skinner's shaft.

The lode in the upper workings was soft and easily mined, and the ore occurred in a compact and pure form, the yield in the 58- and 73-fm. levels being from 1 to $1\frac{1}{2}$ tons per fathom. In the two levels next below $2\frac{1}{2}$ to 3 tons per fathom were frequently obtained, the ore-body having a length of about 140 fms. The impoverishment of the lode began a little above the deep adit (or 118-fm.), and in the 130-fm. level it only yielded from 5 to 16 cwt. per fathom. The lode in the deeper workings thus became very poor and the ground hard, with spots and narrow inconstant strings of ore scattered through it; its width, too, diminished somewhat, and in the bottom level it varied from $2\frac{1}{2}$ to 4 ft.

The ore-body proved by these workings is, roughly, of lenticular form, the centre of the lenticle being at a point in the 88-fm. level about 40 fms. west of Skinner's shaft. A narrow westerly-dipping prolongation of the main mass extended to the surface between Skinner's and the Engine-shaft.

The eastern levels reached, and in places penetrated, the great cross-course which was proved also in the middle workings of Glogfawr, but at Glogfach the cross-course was barren and the lode has never yielded ore to the east; the cross-course formed, therefore, the limit of the workings in that direction. It is curious that, whereas at Glogfawr the lode was richest on the eastern or upthrow side of the cross-course, at Glogfach the productive part is on the western or downthrow side. It is not, therefore, likely that the cross-course has exerted much influence upon the distribution of ore. At Glogfawr, on the other hand, ore was obtained in the cross-course as well as in the lode which it traversed.

At the western end of the mine a western shaft was sunk to the 58-fm. level on a north branch of the lode, which was also reached by a cross-cut from the 58-fm. level on the main lode. It is clear from the plan of the 58- and 103-fm. levels that the Glogfach lode splits up towards the west into two or more branches; this appears to take place about 100 fms. west of Skinner's shaft, and not far from where it became unproductive. West of this point the south branch has been traced on the surface by costean pits for a distance of nearly half a mile, and excavations on the slope north of Llethr farm revealed a narrow lode ranging eastward for Glogfach. About 50 yds. east of the farmhouse a cross-cut was driven north-

westward about 125 fms. Three lodes, the south, middle and north lodes, were cut, but none of them proved of value. The south lode appears to correspond with the outcrop of the Glogfach lode, while the north lode may represent the north branch worked at the western end of that mine. They converge westward and have been tried in the Penlanfach mine, about a third of a mile west of the Llethr cross-cut.

Several attempts have also been made to discover the Glogfach lode in a productive form to the east of the mine, but hitherto without success. About half a mile from the Engine shaft, and on the course of the lode, a shaft called Taylor's, or East Glogfach, was sunk on a lode dipping northward at 62° , and an adit was driven eastward to it. The shaft was sunk to a depth of 15 fms. under the adit on a lode about 5 ft. wide, containing spots of ore; similar material was obtained in the 15-fm. level. At Glogfawr the 60-fm. level from Davey's shaft was driven about 146 fms. eastward on the "north lode" or north branch in that part of the mine, and at this point a cross-cut was driven nearly north-west to prove the Glogfach lode at a depth. At 76 fms. a lode was cut and followed eastward for about 48 fms., but it contained nothing of value; at its eastern end another cross-cut was driven 12 fms. north for further proof. The bearing of this lode does not quite agree with that of the Glogfach workings nor with that of the lode in East Glogfach, but no other lode or branch appears to have been cut. It is probable that the cross-course which passes about 30 fms. east of the Engine shaft, has locally displaced the lode and changed its direction, as, in fact, happens where it crosses the Glogfawr lode.

These various trials render it probable that the Glogfach lode does not exist in a workable form for a distance of at least half a mile to the east of the mine.

Output.

The output can be obtained approximately either from the Mineral Statistics or Messrs. Taylor's reports for the years 1838-40, 1858-80, 1882-9. There is a serious error in the Mineral Statistics for 1857 when Glogfach is credited with the whole of the output of the Lisburne mines.

—	Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Before 1845	Tons. 270	Tons. —	—	Oz. —	Oz. —	Oz. —
Since 1845	9,610½	7,392½	76·9	132,568 ¹	17·1	23·5

¹ Silver is omitted for certain years, probably by oversight. The total silver may be estimated at 169,000 oz.

PENLANFACH.

The Penlanfach mine is on the east side of the road from Ffair Rhos to Ysbytty Ystwyth, and about a mile south of the latter place. The Glogfach lode is supposed to pass through the ground, and between 1877 and 1885 a trial of it was made by driving an adit northwards into the hill from the side of the road to Glogfawr. The adit intersected a lode in a few fathoms, and was driven eastward about 140 fms. Some ore estimated at about half a ton per fathom was obtained in a rise from the adit to the surface about 20 fms. east of the mouth, and bunches yielding from $\frac{1}{4}$ to 1 ton per fathom were met for about 50 fms. eastward; the rest of the driving was unproductive. A shaft was sunk vertically to a depth of 32 fms., or 25 fms. below the adit, and a level was driven 30 fms. west and 40 fms. east of the shaft in a lode varying from 1 to 5 ft. wide, but containing merely spots of lead- and copper-ores. A cross-cut north at the west end intersected a lode of no value at 18 fms.

In recent years another adit driven at a deeper level and about 40 fms. nearer the road intercepted a lode carrying some galena and followed it eastward for 40 fms. This is probably the same lode as that on which the main part of the shallow adit was driven, but in this area several narrow lodes or branches occur close together, probably representing the Glogfach lode in a much-divided and impoverished condition. Immediately west of the road the lodes pass under a thick cover of boulder-clay, and costean pits have there failed to reach solid rock. As the lodes tend to converge westward conditions may become more favourable.

Output.

Probably included with Glogfach.

GLOGFAWR.

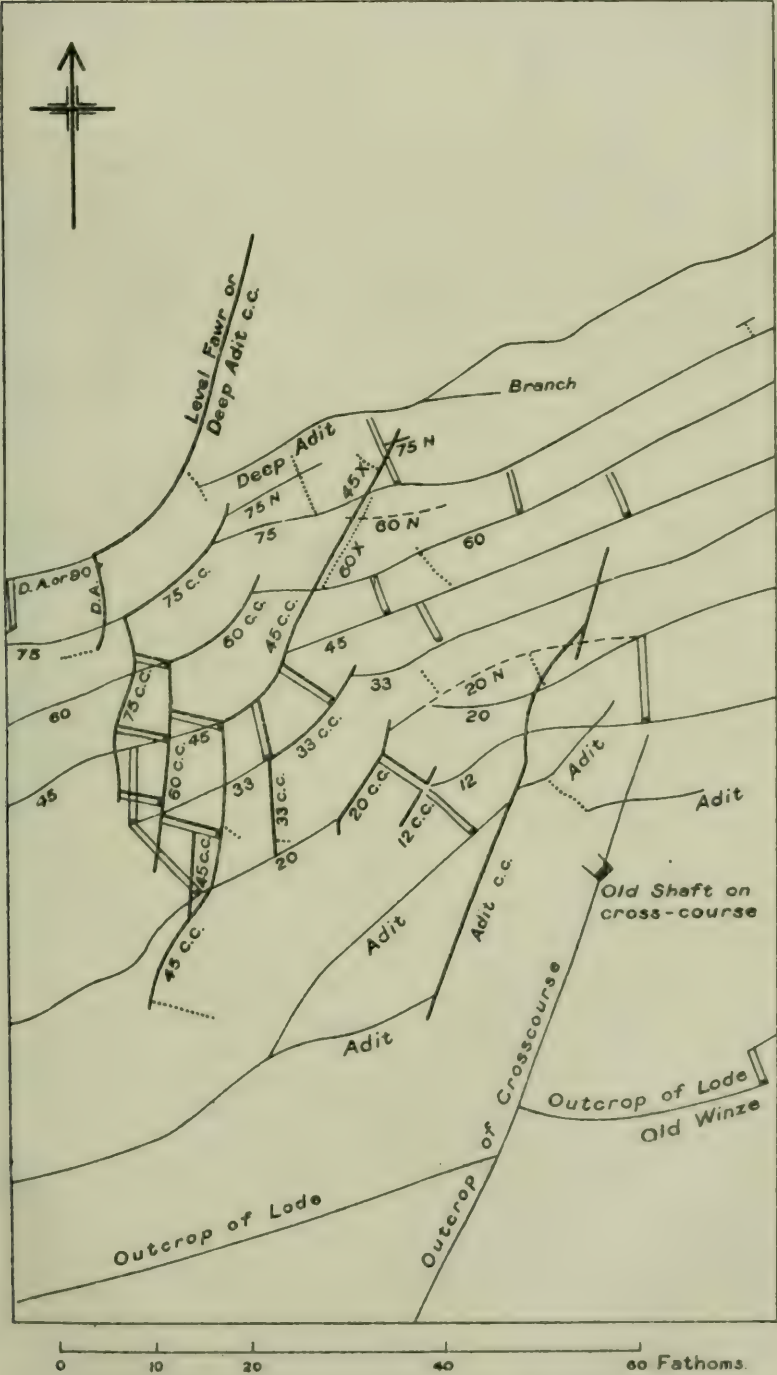
(6-in. Sheet, Card. 16 N.E., Long. 3° 50' 0", Lat. 52° 19' 15".)

Glogfawr is about a mile E.S.E. of Ysbytty Ystwyth, and only about 300 yds. south of Glogfach. It is one of the Lisburne group and was worked by Messrs. Taylor, but shallow workings towards the western end of the mine were in existence prior to 1834. The chief developments were carried out between 1860 and 1892: the engine-shaft being sunk vertically to a 20-fm. level, and subsequently on the lode to a depth of 90 fms. The levels are reckoned from an adit cross-cut (about 1,060 O.D.) driven from a point near the base of the hill about 130 yds. S.E. of the engine-shaft. About 150 yds. farther west is a somewhat shallower adit (about 1,085 O.D.) on a "north lode." After the mine had been worked for many years the deep adit or Level fawr was continued southward from Glogfach, and a winze sunk below the 75-fm. level to the deep adit or

" 95-fthm. level " effected communication and drained the mine a few fathoms deeper than the bottom of the engine-shaft.

Subsequently, about 1880, a trial of the eastern end of the mine was carried out from a shallow adit (Penbwlch adit, about 1,180 O.D.), which was driven westward on the lode to an engine-shaft (Eastern or Penbwlch shaft). This was sunk to the 45-fm. level which was driven eastward from the main workings; the total length of the mine being, therefore, about 520 fms. After Messrs. Taylor had relinquished it, the mine was taken over by the Lisburne Mines Development Syndicate, who sank the new Davey shaft near the outcrop of the lode, 360 yds. N.E. of the old engine-shaft. It was carried down to a depth of about 20 fms. below the deep adit or 90-fm. level, the water from the bottom workings being pumped up to that adit. The 12- and 20-fm. levels and those below the 60-fm. were also extended a considerable distance eastward.

A great cross-course was met in all the levels from the surface down to the deep adit, its width varying from level to level, but lying between 24 and 45 ft. (Pl. XIX). Advantage was taken of the soft ground formed by it in driving the deep adit from Glogfach southwards, but heavy timbering was required and the expense of maintaining it has been considerable. The direction of the cross-course is a few degrees east of north and the dip is west at about 55° to 60° (average, 58°). Its outcrop coincides with a marked hollow now occupied by a reservoir about midway between Davey's shaft and the old engine-shaft, and ranges thence towards the eastern end of Glogfach. In all the levels the Glogfawr lode was displaced about 5 or 6 fms. to the south on its west side and, as the lode is inclined to the north at 55° to 68° , the cross-course behaves as a normal fault with a downthrow west of about $4\frac{1}{2}$ fms. It was found to carry ore at its intersection with the Glogfawr lode, and for a distance of 5 to 15 fms. to the south. That lode was also richer, and the bunches of ore larger and more continuous near the cross-course, particularly on its eastern or upthrow side, than at a distance from it. When the 45-fm. and higher levels were driven eastward from the Penbwlch shaft, another or eastern cross-course having almost the same direction as the other was intersected; its width varied from 11 to 16 ft., and it was said to have a westerly underlie of about one in three or a dip of about 70° . It was hoped that the lode which was impoverished on its western side, would be enriched in the neighbourhood of the new cross-course, but attempts to prove a productive lode in that direction have not hitherto met with success. In the 45-fm. level it consists of a great width of crushed and sheared shales, the walls of the disturbance being ill-defined and the underlie difficult to determine. The appearance of this disturbed belt suggests that it is one of that group of north-and-south faults or strike-faults which are in general of earlier date than the lode-fissures; any influence it may



PLAN OF CLOGFAWR SHOWING
RELATION OF CROSS-COURSE TO THE LODGE .

have exerted upon the lode is likely to have been of an indirect nature. The rocks crushed in the cross-course and those cut through in the 45-fm. level consist in part of a band of soft dark pyritous shales and mudstones which are met in other parts of the mine, and it is clear that the lode is barren for several fathoms west of the point where the cross-course enters the level.

The Distribution of the Ore.—The ore-body which has been explored by the above workings has the form of a shallow basin, its deepest part being in the neighbourhood of the Davey shaft, where the ore has been proved to extend to the 110-fm. level. Eastward it reached the 45-fm. level west of Penbwllch shaft, whence its boundary rose to near the surface in the neighbourhood of the Penbwllch adit; westward it extends between the 10- and 45-fm. levels to 40 or 50 fms. west of the engine-shaft. The richest part of the mine was in the neighbourhood of the western cross-course, both by reason of the cross-course itself being metalliferous, and of the ore in the lode being richer and more continuous in that part of the mine. In the middle levels (about the 45-fm.) the ore formed a rib a few inches wide, usually near the footwall, but in the lower levels (100-fm. and 110-fm.), it tends to be scattered through the width of the lode. According to Messrs. Taylor the lode was much flatter in the upper levels, and the flattening was accompanied by some impoverishment.

Throughout most of the mine the yield was estimated at from 8 to 15 cwt. per fathom of driving, but in the 45- and 60-fm. levels it reached 1 or even $1\frac{1}{2}$ tons per fathom. The lode is not, therefore, a rich one, but the matrix consists largely of soft crushed mudstones and the ground is not difficult to work. Its low average content accounts for considerable areas having been left.

Messrs. Taylor between 1887 and 1891 dressed 39,691 tons of stuff and obtained 1,627 tons of ore, or an average of 1 ton of ore from $24\frac{1}{3}$ tons of rock, and between 1888 and 1891, 1,287 tons of ore were obtained from about 2,460 fms. stoped or driven through ore; this indicates an average yield of about 10 cwt. per fathom. Owing to losses in dressing it may be estimated that the average content of the parts of the lode removed was about 15 cwt. per fathom, or 1 ton of ore in 12 to 15 tons of stuff. In earlier years a somewhat higher yield was obtained.

Taking the limits of the ore-body as a whole it appears that roughly about one-half the area of the lode contained ore in quantities that would at that time pay for working.

A few fathoms west of the Davey shaft the Glogfawr lode splits into two branches which diverge eastwards at a small angle; both branches were productive near the junction, but became poorer eastward.

Again, in the neighbourhood of the old engine-shaft two lodes were worked from the adit to the 45-fm. level. Near

the shaft these lodes were about 12 fms. apart in the adit, and about 6 fms. in the 45-fm level. In the lower levels this "north lode" joins the south lode both east and west of the shaft, and it may probably be regarded as a branch, including a "horse" of country-rock, rather than a distinct lode. Both branches were productive, but became poorer and ultimately barren when traced westward.

Output.

The output can be obtained for the years 1862, 1864-93, 1909-1917.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 18,520 $\frac{3}{4}$	Tons. 14,218 $\frac{3}{4}$	% 76·8	Oz. 64,317 ¹	Oz. 6·65	Oz. 8·6

ESGAIRMWYN.

(6-in. Sheet, Card. 16 S.E., Long. 3° 49' 45", Lat. 52° 18' 20".)

This mine is in the grant of the crown and lies about 2 miles from Pontrhydfendigaid, or about 3 miles by road from Strata Florida station. According to Meyrick ("History of Cardiganshire," p. cexli.) it was discovered about 1751 or 1752 under the superintendence of Lewis Morris, who was then steward for the Crown. It formerly yielded one-third lead-ore and the rest quartz, but just before 1810 it was yielding only one-tenth ore. The ore sold in the year 1806 for about 18*l.* per ton, which indicates that it was comparatively poor in silver; at the same period the ore of Cwmsymlog (East Daren), with about 30 oz. silver, sold for 22*l.* per ton, while that of Llanfairelydogau, with about 50 oz. of silver, fetched 27*l.* per ton. This is a point of interest in view of the recent history of the mine.

The old mine lay to the east of the present workings and was worked by a shaft, the bottom of which appears to have been about 120 fms. below the surface, or about 80 fms. below the deep adit driven in from near the new mine. There is no plan available, but a section indicates that apparently there were four more or less distinct ore-bodies worked, each forming a shoot dipping westward at an angle of 30° to 40° from the vertical. The largest shoot, which extended from the surface into the shaft, was about 30 fms. wide and 90 to 100 fms. high. In the lower part of the shaft there was another shoot, which extended to the bottom.

The new mine is worked from an underlie shaft which is sunk to 145 fms. below the deep adit, or about 155 fms. from the

¹ The total amount of silver may be estimated at 122,700 oz.

surface; it is the second deepest shaft in the district. Levels are extended at 15, 25, 35, 48, 60, 70, 80, 90, 102, 114, 125, 135 and 145 fms. The ore-body revealed by these workings is narrow in the shallower levels but widens gradually downwards to about 70 fathoms at the bottom of the mine. It appears to be distinct from those of the old mine, which dip towards it, and both the 70- and 102-fm. levels were driven eastward under those shoots without success.

In driving the 102-fm. exploration-level westward, a cross-course was cut about 90 fms. west of the shaft. It contained large open cavities or vughs, and in a driving southwards a large volume of water was tapped which rose rapidly and drowned parts of the mine for a time. The flow is now moderate. Probably a large cavity in the cross-course filled with water was broken into.

The lode strikes almost exactly west-south-west and is apparently continued with a slight change of direction into an old mine called Llwynllwyd (or, according to Absalom Francis, South Lisburne), where it has been tried by a shallow adit and several old shafts.

Output.

Lead-ore was returned in the years 1852-7, 1859, 1860, 1870-80, 1883, 1884, 1891-93, 1898-1917.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 10,430	Tons. 7,520	% 72·1	Oz. 122,075 ¹	Oz. 12	Oz. 16·5

Blende—Small amounts were returned in 1884, 1898-1900, 1902, 1903, 1914. Total, 106 tons.

Copper-ore.—In 1909-10 and 1915-17 small parcels of lead-ore mixed with copper-ore were sold; in all about 140 tons, which were estimated to contain about 10 tons of copper.

Change in Silver-Content of the Ore with Depth.—Mr. John Williams, the Manager, has furnished figures showing the silver-content of various parcels of ore obtained from the mine between 1908 and 1919. During this period the mine has been deepened about 20 fms., and, in addition, a winze was put down on the lode about 10 fms. below the 145-fm. level. From these figures it appears that when the ore was derived mainly from the 125-fm. with an admixture from higher parts of the mine, the silver-values were 14 oz. to the ton, and were lower in proportion to the amount of ore obtained from higher levels. When the stopes over the 135-fm. level were worked the

¹ The total amount of silver is understated owing to omissions in certain years; it may be estimated at 124,600 oz.

values varied between 14 oz. and 19 oz., while the stopes from the back of the 145-fm. yielded from 14 to $21\frac{3}{4}$ oz. per ton. Ore from the winze below the 145-fm. contained as much as 26 oz. of silver per ton.

The figures agree, in general, with those returned in the Mineral Statistics, which also give an indication of the character of the ore obtained from above the 80-fm. level. Between 1852 and 1900 the average silver-content varies between 2 and 6 oz. per ton; after 1901 the proportion rises year by year to a maximum of 20 oz. in 1915. Again, in 1911-12 owing to the flooding of the mine some ore was obtained from above the adit in the old mine. It contained less than 7 oz. of silver per ton.

There is, therefore, no doubt that the ore of this mine which in the shallower workings is as poor in silver as most mines in the district, becomes increasingly richer downwards. The bottom samples approximate in silver-content to the ore of such mines as Goginan and the Daren group which were at one time highly prized for their silver.

These results may be expressed by taking averages for groups of five years for which returns of silver were made.

Average Silver per Ton of Ore.				
Oz.				
1852-55	-	-	-	3
1856-60	-	-	-	1.9
1861-70	-	-	-	No returns.
1871-75	-	-	-	3.0
1876-80	-	-	-	5.9
1881-85	-	-	-	4.8
1885-90	-	-	-	No returns.
1891-95	-	-	-	6.0
1896-1900	-	-	-	4.9
1901-05	-	-	-	10.6
1906-10	-	-	-	14.8
1911-15	-	-	-	15.8, including some ore from shallow levels.
1916-18	-	-	-	16.5

ABBEE CONSOLS OR FLORIDA MINE.

(6-in. Sheet, Card. 21 N.E. and 16 S.E., Long. $3^{\circ} 50' 30''$,
Lat. $52^{\circ} 16' 45''$.)

This mine was at one time known as Bronberllan, after the name of the adjoining farm. It lies about one-third of a mile north-west of the ruins of Strata Florida Abbey on the north side of the Teifi valley, and is about 3 miles distant by road from Strata Florida station.

The workings were carried out partly from a shaft which is sunk on the lode to a depth of 50 fms. below the adit, and

partly from the adit (about 690 O.D.), which intersects the lode 23 fms. east of the shaft and drains the mine to a depth of about 25 fms. The lode strikes east-north-east and dips to the south at 55° . The workings are of no great extent; the adit is about 70 fms. in length, and the longest, or 40-fm. level, has been driven only 90 fms.

According to the plan and section preserved in the Home Office, the ore was distributed irregularly along the lode and has the appearance of forming narrow shoots dipping westward. The largest body was found near the surface. Much blende was associated with the galena. The rocks adjoining the lode occupy a high horizon in the Frongoch formation, and are approximately the same as at Esgairwyn.

Output.

Returns of lead-ore are available for the years 1848, 1852, 1856–1861, 1871–1873, 1877, 1878, 1882, 1886–1891, 1893, 1894, 1896–1898, 1905, 1908, 1909.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 1,236	Tons. 895	% 72	Oz. 1,555 ¹	Oz. 2·8	Oz. 3·9

Blende, 1,765 tons. The greatest output was 287 tons of lead-ore, in 1872.

CHAPTER V.

DETAILED DESCRIPTION OF THE MINES (*continued*).

NOTES ON CARDIGANSHIRE MINES WITH A TOTAL OUTPUT OF LESS THAN 1,000 TONS.

(These mines are arranged in alphabetical order.)

ABERFFRWD.

(6-in. Sheet, Card. 11 N.W., Long. $3^{\circ} 56' 0''$, Lat. $52^{\circ} 23' 25''$.)

There are several small workings near the hamlet of Aberffwrdd on the south side of the Rheidol valley about 7 miles from Aberystwyth. There are two adits near the Vale of Rheidol Railway station and an old shaft of unknown depth on a lode which dips steeply to the south. Near Abernant near the south

¹ The amount of silver contained in the whole of the lead-ore may be estimated at 3,475 oz.

side of the railway, about half a mile south-west of Aberffrwd, there are also several shafts on a strong brecciated lode, which is parallel to the above, and dips to the south at 70° to 75° . It is not known which locality is referred to in Mineral Statistics under the above name, but according to A. Francis (p. 83), the Abernant mine was not productive. The country-rocks are high up in the Frongoch formation.

Output.

Returns are available for six years.

Lead-ore	-	-	-	-	236 tons.
Copper-ore	-	-	-	-	5 tons.
Greatest output of lead-ore	-	-	-	-	66 tons (1855).

BLAENCENNANT.

(6-in. Sheet, Card. 11 N.W., Long. $3^{\circ} 54' 45''$, Lat. $52^{\circ} 22' 35''$.)

This mine lies in the higher beds of the Frongoch formation, about $3\frac{1}{2}$ miles due west of Devil's Bridge and nearly the same distance north-west of Frongoch mine. The lode strikes west-south-west, and has been worked from several shafts and shallow adits (900–1,000 O.D.) It is possibly the continuation of a branch given off from the Castell lode near Penrhiw mine.

Output.

Lead-ore	-	-	-	-	72 tons.
Blende	-	-	-	-	62 tons.
Greatest output of lead-ore	-	-	-	-	27 tons (1870).

BLAENCEULAN.

(6-in. Sheet, Card. 4 N.W., Long. $3^{\circ} 53' 30''$, Lat. $52^{\circ} 29' 50''$.)

The workings consist of an adit (about 1,000 O.D.), driven about 120 fms. westward into the Gwestyn shales to an engine-shaft which is sunk in the same rocks. The lode appears to be the most northerly branch of the split-up Esgairhir lode; in the engine-shaft it dips steeply to the north and ranges W. 30° N. The workings are limited to the neighbourhood of a rather rich bunch of lead-ore, associated with a considerable amount of copper-pyrite and some blende; an association which is commonly found in lodes that traverse the Gwestyn rocks.

Near Blaenceulan farm there is an old shaft and an adit on another branch, but there is nothing to show that any ore was obtained.

Output.

Lead-ore was returned for eight years, the greatest output being 250 tons (1871):—

Lead-ore	-	-	-	-	438 tons.
Blende	-	-	-	-	7 tons.
Copper-ore	-	-	-	-	18 tons.

BODCŴLI.

(6-in. Sheet, Card. 11 N.E., Long. $3^{\circ} 49' 15''$, Lat. $52^{\circ} 22' 30''$.)

This mine was known also as Gertrude: it lies near the River Mynach about $1\frac{1}{2}$ miles east of Devil's Bridge, or about two miles by road from the station. The lode appears to be a continuation of that worked to the north-east at Tygwyn or Mynach Vale and Dolwen, and is locally believed to be the Frongoch lode. At the mine it traverses the Frongoch formation and ranges E. 33° N.-W. 33° S., with a steep dip. It consists of a considerable width of shattered country-rocks with quartz and gossan. The ore was drawn through a well-constructed arched adit (about 800 O.D.), measuring 10 ft. by 8 ft., which communicates to a shaft sunk on the lode. According to local accounts a rich bunch of lead-ore was worked, but for some unexplained reason the lode was cut off abruptly in depth.

Lead-ore was returned for seven years. Total output, 348 tons. Greatest output 154 tons (1873).

BRYNARIAN.

(6-in. Sheet, Card. 3 N.E., Long. $3^{\circ} 58' 5''$, Lat. $52^{\circ} 30' 20''$.)

This mine is situated on the group of small lodes which traverse the lower beds of the Frongoch formation on the steep slope east of the village of Taliesin (Tre-Taliesin on the 6-in. map).

The rocks consist mainly of pale-greenish friable mudstones, which are characteristic of this horizon throughout the district. The mine was, for a time, worked in conjunction with Pensarn mine, about 600 yards to the south-east and has had a somewhat chequered history. It was worked mainly from shafts at about 600 ft. O.D. and was partly drained by adits, the lowest being about 240 ft. above O.D.

Output.

This is an old mine and its total output may be a good deal more than appears in the returns. Since 1845 lead-ore has been returned for 7 years.

Lead-ore	-	-	-	-	-	294 tons.
Blende	-	-	-	-	-	53 tons.

The greatest output of lead-ore was 95 tons (1851).

BRYNDYFI OR NEUADDLWYD.

(6-in. Sheet, Card. 2 S.W., Long. $3^{\circ} 56' 10''$, Lat. $52^{\circ} 31' 30''$.)

About 1 mile south-south-east of Furnace, Glandovey. Considerable trials were carried out on a fault which crosses the Gwestyn and Van formations in a direction N.W. to S.E.

Output.

Dressing-plant and floors were prepared, but only 24 tons of lead-ore were sold (1882).

BRYNGLAS.

(6-in. Sheet, Card. 7 S.E., Long. $3^{\circ} 49' 35''$, Lat. $52^{\circ} 25' 0''$.)

This mine lies on the main road about three-quarters of a mile east of Ponterwyd, where two or three small lodes converge from the west to a point near the workings, and then diverge to the north-east. The rocks are the upper beds of the Van formation. The workings embrace a shaft sunk by the road-side, an adit (about 785 O.D.) which is driven under the road in a north-easterly direction, and various trials at a higher level.

One of the lodes is exposed in the bed of the River Castell to the west; the other ranges towards the school, west of which the two unite and traverse the base of the Frongoch formation west of Ponterwyd.

Output.

The mine returned ore for two years only; the total output was 41 tons of lead-ore, of which 32 tons were produced in 1860.

BWADRAIN S.

(6-in. Sheet, Card. 11 N.E.)

This consists of a shaft and adit on a lode called the Simddelwyd lode, east of Nant Bwadrain and about half a mile south-east of Bwadrain mine. It only returned 3 tons of blende (1876).

CAMDWRBACH.

(Also known as Cambrian South).

(6-in. Sheet, Card. 4 N.E., Long. $3^{\circ} 50' 50''$, Lat. $52^{\circ} 29' 10''$.)

This trial was carried out in the upper beds of the Van formation, about a mile north of Brynrafr mine. An adit (about 1,200 O.D.) was driven eastward for a considerable distance on what is possibly the continuation of the Eaglebrook lode. Before any adequate test had been made, extensive dressing-plant and large buildings were put up near the road by Camdwrbach.

Output.

Ore was returned on two occasions only. The total output was 26 tons of blende, of which 21 tons were returned in 1904.

When the mine failed the machinery was transferred to the Llettyhen or Vaughan mine.

CAMDWRMAWR.

(6-in. Sheet, Card. 4 S.E., Long. $3^{\circ} 50' 10''$, Lat. $52^{\circ} 28' 20''$.)

This trial consists of an adit (about 1,230 O.D.), driven eastward on the main Camdwr lode for a considerable but

unknown distance. A. Francis states (p. 13) that an engine-shaft was sunk 30 fms. below the adit. The adjoining rocks pertain to the uppermost part of the Van formation.

Output.

The only record of lead-ore sold is in 1856 (5 tons). The trial has been continued on at least two occasions in later years but apparently without success.

CARON.

Exact position unknown. Probably one of the small mines east of the G.W. Railway, north of Tregaron.

CEFNGWYN.

(6-in. Sheet, Card. 4 S.W., Long. $3^{\circ} 56' 40''$, Lat. $52^{\circ} 27' 50''$.)

This mine lies among the lower beds of the Frongoch formation in the Leri valley, half a mile below Elerch or Bontgoch. There are two sets of workings; a section of part of them is preserved in the Home Office. An adit has been driven from each side of the valley on the Hafan or south lode, the eastern adit extending about 60 fms., and the western about 45 fms. 80 yds. to the north there was an engine-shaft, about 20 fms. deep, on a small irregular north lode dipping steeply to the north. The dressing-floors extended along the narrow floor of the valley.

Output.

There are returns of lead-ore for nine years, totalling 150 tons, the greatest output being 29 tons (1881).

CLARA.

(6-in. Sheet, Card. 7 S.E., Long. $3^{\circ} 51' 25''$, Lat. $52^{\circ} 24' 30''$.)

This mine lies by the side of the Aberystwyth-Llanidloes road at the 11th milestone from Aberystwyth, and was worked from a shaft about 30 yds. south of the road. The lode is probably either the main Brynglas lode or a branch of it. Close to the road, on the north side, there are workings almost up to the outcrop; the dumps from them contain large masses of blende in strings and veins up to 4 in. in width. There is a good deal of similar material in the dumps surrounding the engine-shaft, which also contain some galena and a little marcasite. There is evidence of a considerable amount of work having been done at the mine.

Output.

Returns are available for 11 years :—

Lead-ore	-	-	-	-	-	194 tons.
Blende	-	-	-	-	-	30 „

The greatest output of lead-ore was 40 tons (1871, 1872).

CWMMDAREN, LEVEL GOPOR, OR COPPER LEVEL.

(6-in. Sheet, Card. 7 N.W., Long. $3^{\circ} 56' 25''$, Lat. $52^{\circ} 25' 55''$.)

The adit called the Copper Level (about 425 O.D.) is on the north side of the road to Cwmsebon or South Daren, and about 600 yds. to the westward of that mine. It has been driven with a rise of about 2 in. in the yard for about 150 fms. on the Daren lode, and 70 fms. from its mouth an engine-shaft has been sunk to a depth of 50 fms. below it. The adjoining rocks are similar to those of Daren and South Daren, but the lode yielded a larger proportion of copper-ore than at either of those mines.

About 120 fms. north-east of the shaft an old adit (about 585 O.D.), called the Roman adit, has been driven on this lode, or a branch from it, to the Cerigyrwyn shaft, where it is said that some rich lead-ore was once obtained. About one-quarter of a mile farther in the same direction is Gwaithyrafon, situated on the same general lode belt, but possibly joined here by the north branch of the East Daren lode.

Output.

The mine has returned 121 tons of lead-ore and 94 tons of copper-ore, the greatest output of lead-ore being 50 tons (1855).

CWMERFIN W.

(See Melindwr Valley.)

CWMMAWR.

(6-in. Sheet, Card. 16 S.E., Long. $3^{\circ} 51' 15''$, Lat. $52^{\circ} 17' 20''$.)

The mine stands a quarter of a mile due east of the school, half a mile north of Pontrhydfendigaid, and about 2 miles by road from Strata Florida station (G.W. Railway).

It was worked by a shaft sunk to a depth of 20 fms. below a shallow adit (about 650 O.D.), which was driven eastward on the lode. The lode ranges east-north-east and dips to the north; it lies high up in the Frongoch formation.

Output.

Ore was returned between 1913 and 1917, when the mine stopped working, and later on was dismantled.

Lead-ore	-	-	-	-	-	836 tons.
Blende	-	-	-	-	-	131 „

The maximum output of lead-ore was 358 tons (1914).

CWMPRYF.

Exact situation unknown; it appears to be a trial in the Rheidol valley. It returned lead-ore for three years to a total of 51 tons. The maximum output was 30 tons (1880).

CWMYSTWYTH, S.

These workings lie south of the River Ystwyth, opposite Cwmystwyth mine. They are, therefore, south of the Ystwyth fault in country-rocks which are a few hundred feet below the base of the Cwmystwyth formation. The rocks are somewhat harder and less pyritous than those which occupy a corresponding position north of the fault.

There are three sets of explorations :—

(1) A cross-cut (777 ft. above O.D.) starts at the base of the slope, 200 yds. east of Bwlchgwynt. It was driven south-east for 140 fms., then south-south-east for 200 fms., at which point it was abandoned in 1884.

The only lode of any importance was cut at 30 fms. from the mouth, and was followed for 110 fms. eastward. It is shown in a transverse section preserved in the Home Office as being about 3 fms. wide and dipping to the south at 75° . Some good specimens of blende, associated with débris of a strong lode, which lie on the dumps, were probably derived from it. Two small northerly-dipping branches were cut at 120 and 140 fms. from the mouth.

(2) Three adit cross-cuts were driven into a south-dipping lode, on the slope opposite the Cwmystwyth dressing-floors. The upper is about 1,010 ft., the intermediate 920 ft., and the lower or No. 2 cross-cut 860 ft. above Ordnance Datum.

The lode ranges, approximately, for that which was met in the cross-cut described above, and may probably be correlated with it.

(3) The third set of workings are about 200 yds. east of those last described, and consist of an adit cross-cut (767 ft. above O.D.) which has been extended southward for 95 fms., and a shaft sunk to 24 fms. on a south-dipping lode. The levels range, approximately, towards the central workings, and are probably on the same lode. On the plan the lode in the eastern workings is referred to as the Pengeulan lode, but this can hardly be correct as the Ystwyth fault intervenes.

The trials are of interest chiefly in the light they throw upon the eastward continuation of the Logaulas lode. Various features indicate that that lode ranges for the base of the slope south of the River Ystwyth, and approximately parallel to the outcrop of the Comet lode which lies north of the Ystwyth fault. The lode proved in the workings may, therefore, be the Logaulas, though there is room for a lode to pass north of the trials along the lower slope of the valley. The various cross-cuts show clearly that no such lode exists farther south.

Output.

Lead-ore was returned in 1878 only (40 tons).

CWMYSTWYTH, W.

These workings consist of adits driven eastward on the Comet lode from the stream north of Pentre Briwnant, or about a mile west of Cwmystwyth mine. At a later period a cross-cut was driven northward from opposite Fron house to intersect the same lodes. The adits have been extended about 100 fms. on it, but little ore was obtained from them.

Another set of workings under the above name lie near the road west of Bwlchgwynt. A cross-cut was driven from the roadside in a north-north-west direction for about 470 fms., and passed through a width of nearly 30 fms. of soft ground (Ystwyth fault). North of this no important lode seems to have been recognised though the cross-cut has been extended sufficiently far to have intersected the Comet lode and its subsidiary fractures. South of the Ystwyth fault a north dipping lode (Penparc lode) has been worked at some time at various levels.

Output.

Lead-ore, 20 tons.

CWMSYMLOG, W. AND N.

These names appear to refer to trials near East Daren mine. Their precise locality cannot be identified, and the lead-ore returned from them is only 18 tons.

DOLWEN OR DE BROKE.

(6-in. Sheet, Card. 12 N.W., Long. $3^{\circ} 47' 30''$, Lat. $52^{\circ} 23' 15''$.)

Dolwen mine stands on the spur between the Mýherin and Mynach valleys, at an altitude of nearly 1,400 ft. There is no road within a considerable distance of the mine and access to it is difficult. In spite of these handicaps it maintained a fairly high output of ore for several years. The lode ranges S.W. towards Tygwyn or Mynach Vale mine, and dips to the south-east at 65° to 70° . It is several feet wide and consists of brecciated mudstones belonging to the Ffrongoch formation, with quartz.

The main workings were carried out from an underlie shaft on the summit of the hill, and were partially drained by a shallow adit. The lode cannot be traced continuously in a south-westerly direction, but at a distance of half a mile, near the River Mynach, there are old shafts and an adit (about 870 O.D.) on a similar lode and having the same dip and strike. At this point it enters the Tygwyn property on the south side of the stream.

The lode near the river carries a good deal of blende and copper-pyrite in association with calcite; these minerals are absent on the summit of the hill, and possibly the Dolwen workings are on a branch of the lode which was worked near the river and at Mynach Vale. It is probable that the same lode continues south-westward to Bodcoll. There is some doubt whether the mine known as De Broke is Dolwen or the adjoining Mynach Vale mine. A. Francis (p. 94) describes the latter under this name, whereas in the Mineral Statistics for 1877 and later years the name "De Broke or Dolwen" appears among the Cardiganshire mines. The returns from De Broke are here included with Dolwen though judging from the limited workings and small returns from the latter it is probable that Francis is correct.

Output.

Lead-ore was returned for 10 years; the total output was 831 tons (Dolwen alone returned only 3 tons), the maximum being 221 tons (1877).

DOLCLETWR OR LLAINHIR.

(6-in. Sheet, Card. 3 N.E., Long. $3^{\circ} 58' 35''$, Lat. $52^{\circ} 30' 30''$.)

This mine consists of a shaft at an altitude of about 90 ft. above O.D., on the east side of the main road about 300 yds. south of Treddol village; it is sunk in the Gwestyn formation. The lode yielded blende, copper-pyrite and galena, in order of abundance as named. It is noteworthy as another instance of a lode in the Gwestyn shales carrying a relatively high proportion of copper-pyrite and blende.

Output.

The mine returned ore for four years :—

Lead-ore	-	-	-	-	-	16 tons.
Blende	-	-	-	-	-	147 "
Copper-pyrite	-	-	-	-	-	80 "

EAGLEBROOK OR NANTYCAGAL.

(6-in. Sheet, Card. 4 N.E., Long. $3^{\circ} 51' 45''$, Lat. $52^{\circ} 29' 10''$.)

This mine lies west of the road from Talybont to Brynrafr mine, and about 7 miles from the former place. The lode traverses an anticline in Van mudstones and underlying grits, which are thrown down by it about 20 yds. to the north. The lode dips north at a fairly high angle, and is composed of shattered grits associated with dolomite, copper-pyrite and much gossan; it is more decomposed and carries a greater variety of secondary minerals than most of the lodes of the district. It was worked by several old shafts which were sunk to a 10-fm. level within the grit-outcrop and most of the ore was obtained from them. More recently another shaft was sunk near the

road into the Van mudstones, but little ore was obtained. The lode cannot be traced either east or west into the base of the Frongoch formation, which is only about 350 yds. from the mine; the downthrow is, therefore, greatest where the lode crosses the axis of the anticline.

Output.

The mine returned ore for 10 years. Its output of lead-ore was 598 tons and of copper-ore 71 tons, the greatest amount of lead-ore obtained being 152 tons (1856).

ELGAR.

(6-in. Sheet, Card. 3 S.E., Long. $3^{\circ} 58' 15''$, Lat. $52^{\circ} 27' 20''$.)

Elgar is the most westerly mine on the Hafan lode. It lies about $1\frac{1}{4}$ miles west of Elerch and about 3 miles by road from Llandre station. The country-rocks occupy a position high above the base of the Frongoch formation.

The workings consist of a shaft and an adit (490 O.D.) which drains the shaft to a depth of about 30 fms. According to A. Francis (p. 16) the lode is about 18 ft. wide and the adit has been driven mainly eastward on a part of it. It was said to be productive but there is no record of any ore having been returned prior to 1889. Francis states that, 20 fms. east of the cross-cut, another lode which he identified as the Penycefn or Court Grange north lode (*see* p. 61), was found to the south of the adit.

Output.

Since 1889 only four tons of lead-ore have been returned, but there is reason to believe that in earlier years a good deal of ore was raised of which no returns are available.

ERGLODD.

(6-in. Sheet, Card. 3 N.E., Long. $3^{\circ} 58' 35''$, Lat. $52^{\circ} 29' 45''$.)

This mine consists of a shaft on the ridge east of Erglodd farm, about three-quarters of a mile north of Talybont, and a shallow adit (about 370 O.D.). Francis states that about 1840 the workings were 11 fathoms under the adit. A lower adit (about 180 O.D.) was commenced, and some pyritous lode-matter occurs on the tip, but the main lode does not appear to have been reached. In this locality very large lumps or "tumblers" of pure lead-ore were found in trenching operations. One of these, discovered near Erglodd farmhouse, weighed several tons.

Output.

The only returns from this mine since 1845 are 16 tons of lead-ore and 12 tons of blende.

GELLI'REIRIN OR GELLI.

(6-in. Sheet, Card. 7 S.W., Long. $3^{\circ} 54' 20''$, Lat. $52^{\circ} 23' 52''$.)

This mine stands by the side of the road and close to the River Rheidol, about 3 miles below Devil's Bridge. The most important workings were carried out about 1800, and the principal returns were obtained during those early operations.

The history of the mine is given by Francis (p. 76). The ore appears to have been discovered on the hillside near the head of "the stag," and is said to have formed an almost solid vein 6 ft. wide.

Bonsall's level (about 530 O.D.), which appears to be that under the fore feet of the stag, was driven northwards to intersect the lode, which was worked from there to the surface and for at least 20 fms. below. The ore-body was about 60 fms. long.

About 1835 a deep adit (about 210 O.D.) was driven towards the lode from near the roadside west of the old workings, but was apparently not completed for many years. Some further workings were carried out between 1856 and 1864 and, according to Francis, 200 to 300 tons of ore were recovered from the old waste-heaps.

Output.

The returns since 1845 show a total output of 706 tons of lead-ore, the greatest amount being 209 tons in 1859.

GLANRHEIDOL.

Identity not known. It returned 73 tons of ore in 1866, but is not mentioned in any other year.

GOGINAN, W.

(6-in. Sheet, Card. 7 S.W., Long. $3^{\circ} 57' 20''$, Lat. $52^{\circ} 24' 30''$.)

This is a trial which is supposed to be on the westward continuation of the Goginan lode, about a mile and a quarter west of Goginan. An adit cross-cut (about 230 O.D.) has been driven northward from the base of the slope west of Cyncoed farm; it meets the lode at 105 fms. from the mouth. Near this point a shaft extends from the surface to a depth of 48 fms. below the adit, and levels have been driven at 12-fm. intervals for short distances.

The course of these levels as represented on the plan which is preserved in the Home Office suggests that the lode is not well defined. It ranges, approximately, east-and-west and dips steeply to the south. Although the Goginan lode is said to range in this direction, the main part of that lode which is seen near the Goginan dressing-floors would appear to be some distance farther north. At the western end of that mine a south branch has been proved

to spring off from the main lode and it is possibly this branch that has been met in the trial.

Output.

Seven tons of lead-ore.

GROGWYNION N. OR PANTAUHIRION.

(6-in. Sheet, Card. 11 S.W., Long. $3^{\circ} 54' 10''$, Lat. $52^{\circ} 20' 15''$.)

A shaft was sunk near Pantauhirion, half a mile northwest of Grogwynion, on a lode which is probably an offshoot from the group worked in that mine.

Output.

The mine is said to have yielded a considerable amount of lead-ore, but the returns only show a total output of 62 tons, of which 60 tons were obtained in 1882.

GWAITHGOCH.

(6-in. Sheet, Card. 16 N.W., Long. $3^{\circ} 53' 50''$, Lat. $52^{\circ} 20' 5''$.)

This mine lies to the westward of Grogwynion and on the north side of the Ystwyth valley, about 2 miles below Pontrhydygroes. There are at least two lodes, one of which is probably continuous with the No. 1, or south lode, of Grogwynion, and the other appears to be the No. 2, combined perhaps with the No. 3 lode of that mine, which has swung round so as to approach the No. 1 lode. The ground has been explored from four adits; three of these are within the Gwaithgoch boundary, but the fourth, or Level y Nant (about 570 O.D.) has been driven in from Grogwynion on the No. 1 lode. The lowest, or No. 3 adit, is a cross-cut which intersects a lode at about 70 fms. from the mouth, and has been driven a considerable distance east and west on it; about 66 fms. east of the point where it enters the lode a cross-cut was extended northward for 20 fms., and met another lode which appears to converge westward towards the first.

The mouth of the No. 1 adit (about 850 O.D.) is in the gully about 170 yds. west of No. 3; the level has been driven eastward on a lode, and a winze goes down into No. 3 level.

No. 2 adit (also about 850 O.D.) is a cross-cut to the north of No. 3, and enters the same lode. The ore which has been obtained from this mine was got near the junction of the two lodes explored in the No. 3 adit, which appear to cross one another where the adit enters the lode.

From Level y Nant a cross-cut was driven north for about 80 fms. from the No. 1 lode of Grogwynion, at a point a few fathoms within the Gwaithgoch boundary. In addition to small branches, three lodes were crossed which may probably be correlated with Nos. 2, 3 and 4 of Grogwynion. No. 2 is 5 to 6 ft. wide; No. 3, about 18 in., and No. 4 about 4 ft. wide, but

none of them appear to have been productive at that point. The connection between these lodes and those in the Gwaithgoch adits has not been established.

Preparations have recently been made to reopen this mine, and a winze sunk below the No. 3 level has yielded rich blende, which is of interest in containing 12.4 oz. of silver to the ton of ore.

Output.

The mine has returned lead-ore for four years, the total being 104 tons and the maximum output 35 tons (1860).

HAFAN AND HENFWLCH.

(6-in. Sheet, Card. 4 S.E., Long. $3^{\circ} 51' 45''$, Lat. $52^{\circ} 28' 30''$.)

The Hafan mine is situated on the Hafan lode, about three-quarters of a mile west of Brynryfafr. Henfwlch is probably on the same lode or a branch of it. At Hafan, an anticline brings to the surface the Gwestyn shales and the Van grits and mudstones. On the eastern limb of the anticline there are two powerful fractures about 120 yds. apart, but they appear to unite westwards. These two fractures were proved generally through the workings, and the ore may therefore occur in a great width of lode matter. Both fractures dip to the south, and they approach one another in depth. From the gully on the western flank of the anticline, five adits situated at 1,244, 1,216, 1,115, 981 and 927 ft. above Ordnance Datum, have been driven eastward on some part of the lode. The Henfwlch adit (1,214 ft. O.D.) also enters the lode from the north-east and drains the principal or Hafan shaft to a depth of 24 fms. About 83 fms. farther west the Bog shaft is drained by the same adit.

According to Smyth, the lead-ore occurred in association with abundant calcite; some copper-pyrite and blende were also obtained.

Output.

Lead-ore was returned for six years, the total output being 623 tons and the maximum output 261 tons (1864). Blende, 4 tons; copper-ore, 25 tons.

HENDREFELEN OR ELLA.

(6-in. Sheet, Card. 16 N.E., Long. $3^{\circ} 53' 0''$; Lat. $52^{\circ} 18' 40''$.)

The trials which were made under the above names lie west of Hendrefelen farm, about $1\frac{1}{4}$ miles south-west of Ysbytty Ystwyth. The lode ranges north-east and dips to the north-west at about 75° ; from its position relative to the Logaulas lode, which is about a quarter of a mile farther north, it is probably the continuation of the Penygist lode, which has a similar dip. It traverses massive grits and shales which belong to the lower beds of the Frongoch formation and only occur at

this horizon in the hills north of Strata Florida. The workings were carried on from a shaft; an adit (about 880 O.D.) has been driven into the lode from the base of the hill north of Hendrefelen, but it is not known whether it reaches the shaft, which is over 700 yds. distant.

Output.

These trials did not meet with success, as 20 tons of lead-ore were returned in 1870 only.

LERI, LERI VALLEY, OR PENPONTBREN UCHAF.

(6-in. Sheet, Card. 4 S.W., Long. $3^{\circ} 57' 5''$, Lat. $52^{\circ} 28' 35''$.)

This is a trial on the south side of the River Leri, about $1\frac{1}{4}$ miles east of Talybont. The lode ranges about E. 25° S., and traverses the lower beds of the Frongoch formation; it dips south at about 75° . Two adit cross-cuts were driven to intersect it; in the upper (about 560 O.D.) the lode is ill-defined, but has yielded some ore. The lower adit (about 300 O.D.) met the lode about 70 fms. from the mouth, but the ore, consisting of spots and strings of galena with some blende and spots of copper-pyrite associated with dolomite, is sparsely distributed. It is not likely that much remains.

Output.

The mine was working for six years between 1858 and 1879 and yielded 212 tons of lead-ore, the greatest output being 79 tons in 1858.

Blende, 109 tons; copper-ore, 5 tons.

LISBURNE, NEW.

Situation not known; in the Mineral Statistics for 1875 it is referred to as being near Pontrhydygroes.

Output.

Thirteen tons of lead-ore.

LISBURNE, S.

(6-in. Sheet Card. 16 S.E., Long. $3^{\circ} 50' 25''$, Lat. $52^{\circ} 18' 5''$.)

It would appear from A. Francis (p. 136) that this name was applied to the Llwynllwyd mine which is on the Esgairmwyn lode, about three-quarters of a mile south-west of that mine. The mine lies just to the west of the probable continuation of the great cross-course of Glogfawr. It was worked mainly from a shaft, and apparently under considerable disadvantages, but yielded a fair amount of ore. More recently, an adit (about 980 O.D.) was driven southward to the lode, which is said to be 12 ft. wide and of promising appearance; near the shaft it dips

to the north-west at 65°. The dumps from the shaft and the deep adit contain a large amount of blende, which must exist in considerable quantities in the lode.

Output.

The mine was only working for three years after 1845, but yielded 131 tons of galena and 599 tons of blende, the maximum output of lead-ore being 64 tons in 1860.

LLANBADARN.

The situation of this mine is unknown; in 1848 there is a return of 33 tons of lead-ore under this name.

LLANCYNFELYN.

(6-in. Sheet, Card. 3 N.E., Long. 3° 59' 15", Lat. 52° 30' 35".)

These workings consist of several old shafts sunk either on the marsh or on a low knoll, about half a mile west of Treddol village. According to Francis (p. 3), the mine reached a depth of 40 fms., but had not then been worked for a long period; it is supposed that at one time large quantities of lead-ore were obtained from it. There are several small lodes which form junctions with one another, and the ore-bodies were found near the junctions.

Output.

Since 1845 the mine has only returned ore on two occasions. Total output of lead-ore, 25 tons.

LLANERCH.

An unimportant trial in the Leri valley, just above Bontgoch or Elerch; only 4 tons of lead-ore were returned.

LLAWRCWMBACH.

(6-in. Sheet, Card. 7 N.W., Long. 3° 54' 5", Lat. 52° 27' 0".)

This mine lies on the north side of the Leri Valley, just below the Craigypistyll waterfall. It is difficult of access by road, and is about 7 miles distant from Bow Street station. The workings appear to be on branches of the Camdwr lode which passes along the floor of the valley to the south, but it is possible that the main lode was entered at a depth. Most of the ore was worked from a shaft which is about 30 fms. deep.

The country-rocks belong to the lowest part of the Ffrongoch formation, which are thrown by the Camdwr lode against the Gwestyn shales.

Output.

The mine returned lead-ore for 19 years; the total output is 477 tons, and the maximum output 100 tons (1859).

LLECHWEDDHEN OR ALMA.

(6-in Sheet, Card. 6 N.E., Long. $3^{\circ} 58' 0''$, Lat. $52^{\circ} 26' 0''$.)

This mine adjoins Bronfloyd on the east, and is probably drained by the old Bronfloyd adit (about 275 O.D.). The shaft is about 35 fms. east of No. 1 Bronfloyd shaft, and is sunk on the lode.

Output.

Although there are returns for two years only (1852, 1853), the mine produced 184 tons of lead-ore, the output for 1853 being 161 tons.

LLECHWEDDHELYG.

This is a small trial on the Camdwr lode in the valley west of the mouth of the Llettyhen deep adit; the lode is very wide and of promising appearance, but only 3 tons of lead-ore were returned (1853).

LLETTYHEN OR VAUGHAN.

(6-in. Sheet, Card. 7 N.W., Long. $3^{\circ} 56' 10''$, Lat. $51^{\circ} 26' 40''$.)

(Mouth of deep adit and recent dressing-floors.)

The deep adit to this mine opens into a narrow valley 1 mile south of Elerch; the workings are more than half a mile to the eastward on the Camdwr lode. Bow Street station is about 6 miles distant by road. The mine, which is about half a mile south-east of the farmhouse, came into existence as the result of the discovery about 1845 of large masses of solid "steel ore" near the surface. Shafts were sunk on the lode, and a shallow adit (about 850 O.D.) was driven in from the south; the shaft ultimately attained a depth of 30 fms. under the adit.

More recently (about 1860) a deep adit or 52-fm. level (about 530 O.D.) was driven eastward, mainly on the lode, underneath the old workings, and the shaft was carried down to it. The result was disappointing, for the bunches of ore did not persist down to the deep adit, and, in spite of the great width of the lode (120 ft. at least), the mine at that depth was all but barren.

At several points on the surface and in the deep adit, pockets of manganese-ore were found in association with reddish and pink-stained shales. These pockets seem, in all cases, to lie near the footwall of the lode, or even below it in the adjoining country-rock, while the lead-ore so far discovered occurred near the hanging-wall.

The country-rocks are grey shales belonging to a fairly high horizon in the Frongoch formation.

Output.

Returns from this mine were made for 13 years, mainly in the years 1851-7 and 1878-81. Total output.—Lead-ore, 581 tons; blende, 282 tons. Maximum output of lead-ore, 177 tons (1878).

LLWYNMALUS.

(6-in. Sheet, Card. 16 S.W., Long. $3^{\circ} 55' 20''$, Lat. $52^{\circ} 17' 35''$.)

The mine is a quarter of a mile west of Llwynmalus farm, and about a mile west-north-west of Ystrad Meurig. The distance by road to Strata Florida station is about $2\frac{1}{2}$ miles. The lode ranges about E. 30° N. and dips to the north at about 75° ; it traverses grey, slaty rocks which are some distance above the base of the Frongoch formation and overlie the grit-group of the Ystrad Meurig district; they are associated also with rusty-weathering shaly bands. The workings were carried out from an underlie engine-shaft, drained to the depth of a few fathoms by a shallow adit (about 810 O.D.) which was driven westward on the lode from a point about 100 fms. to the east. The engine-shaft is about 56 fms. below the adit, but at a later period a vertical shaft was sunk 90 fms. to the west, to intersect the lode at the 50-fm. level.

Output.

The mine was working fairly continuously between 1845 and 1858, and again at intervals between 1862 and 1867. It returned ore for 14 years, the total output being 786 tons lead-ore and 20 tons of blende. The maximum output of lead-ore was 101 tons (1856).

MELINDWR VALLEY, TY'NYPWLL OR CWMERFIN W.

(6-in. Sheet, Card. 7 S.W., Long. $3^{\circ} 56' 45''$, Lat. $52^{\circ} 25' 0''$.)

This consists of a number of cross-cuts, shafts and other workings, designed to test the ground in the westerly continuation of the Goginan, Cwmerfin and Daren lodes.

There are three sets of workings:—

(1) An adit cross-cut (about 320 O.D.), which was started from the east side of the dingle 200 yds. north of the Melindwr stream, and driven at first north and then north-north-west; it was intended to prove the junction of the Daren and South Daren lodes, which was conjectured to occur at a distance of about 550 fms. from the adit-mouth. After being driven in that direction about 300 fms., it was abandoned (Nov., 1876) without making any discovery.

(2) Another adit cross-cut (about 300 O.D.) was driven north-west from the slope, about 220 yds. east of the former. It cut two lodes, one at 15 fms. and the other at 80 fms. from the mouth; the first was only followed for about 25 fms. eastward. On the second, the adit was extended about 130 fms. eastward and 70 fms. westward. Near this end a shaft was sunk on the lode to a 50-fm. level, and the 14- and 26-fm. levels were driven a considerable distance. The lode dips to the north at about 70° , and its average strike is nearly N.E.-S.W.

Ore was found in some quantity in the adit, but the bunches were short and few of them persisted into the lower levels.

It is not probable that this lode is the Cwmerfin lode, as was supposed; it underlies to the north instead of to the south, and its strike would carry it far to the west of that mine. It does not appear to have been met elsewhere. The position and strike of the lode near the mouth of the cross-cut suggest that it may represent the Cwmerfin lode, but nothing further is known about it at this point.

(3) Near the junction of the Ty'nypwll and Melindwr streams, a shaft was sunk to a depth of 25 fms.; the lode reached was only driven on for a few fathoms; a cross-cut north was also put out to a distance of 60 fms, but no discovery was made.

It would appear from these explorations that the lode in the shaft is the same as that near the mouth of the No. 2 adit and, if so, it seems to have a southerly dip. The three cross-cuts made at this locality prove between them a tract of ground extending for 400 fms. across the trend of the lodes. They show, moreover, that at this locality the main lode of Goginan must lie to the south of the Melindwr stream.

Output.

The mine returned lead-ore between 1874 and 1878; total, 186 tons. The greatest output was 100 tons (1875).

MOELGLOMEN.

This name is given to an unimportant trial on a small fracture ranging parallel, and to the north of, the Hafan lode, a quarter of a mile west of Bwlchglas farm. Only about 1 ton of lead-ore was returned (1865).

MYNACH VALE OR TYGWYN.

(6-in. Sheet, Card. 12 N.W., Long. $3^{\circ} 48' 15''$, Lat. $52^{\circ} 22' 55''$.)

This mine is situated near the junction of the Rhuddnant and Myherin streams, where they unite to form the Mynach, which enters the Rheidol at Devil's Bridge. The distance to Devil's Bridge station is nearly 3 miles, and for 2 miles the road is poor.

There are two shafts to the lode, which dips S.E. at 65° . The western shaft is on the lode and reaches a depth of 25 fms.; the eastern shaft, near the mine buildings, is sunk vertically 50 fms. below a shallow adit (about 850 O.D.). Ore was found in most of the levels down to the bottom, but the best ground is near the east end of the mine.

The material on the dumps contains a considerable amount of copper-pyrite in association with blende and some calcite. The country-rocks are high above the base of the Frongoch formation.

Output.

Lead-ore was returned for six years; the total output is 194 tons, and the maximum output 96 tons (1882). (See also Dolwen or De Broke, p. 136).

NEW BOG, TREDDOL.

It is not known to which of the mines near Treddol this name was applied. It only yielded 6 tons of lead-ore (1887).

PANTMAWR, ALSO KNOWN AS IMPERIAL.

(6-in. Sheet, Card. 11 N.W., Long. $3^{\circ} 54' 20''$, Lat. $52^{\circ} 23' 20''$.)

This mine worked the Nantglas lode north of the road from Aberystwyth to Devil's Bridge, immediately west of the ninth milestone. An adit cross-cut (about 790 O.D.) was driven south (about 1845) from near the stream a quarter of a mile south-east of Pantmawr farm; it intersected the lode at a depth of about 15 fms., according to Francis (p. 85), and was driven eastward on it to the boundary. About 1860 the mine was again working, apparently under the name of Silver Mountain, and was then deepened to 25 fms. under the adit. Communication was effected with the western end of the Nantglas workings on the same lode.

Output.

There are only four returns from Pantmawr and three from Silver Mountain. The total outputs of lead-ore are: Pantmawr, 121 tons; Silver Mountain, 143 tons.

PENPONTBREN AND PENYBANC.

(6-in. Sheet, Card. 3 N.E., Long. $3^{\circ} 58' 35''$, Lat. $52^{\circ} 29' 27''$.)

Penpontbren and Penybanc are two old mines, adjacent to one another, on the group of lodes which cross the ridge about half a mile north of Talybont. An adit (about 315 O.D.) has been driven in from the east, and another (about 350 O.D.) from the west side of the hill near Hobson's shaft, but most of the workings were from the shafts on the ridge. It is probable that the ground above these adits, on the plexus of small lodes that occurs in this locality, has been exhausted, but it does not appear that much has been done below them.

Output.

Penpontbren has returned ore for eight years; the total output was 334 tons of lead-ore and 76 tons of blende. The greatest output of lead-ore was 100 tons in 1862.

Penybanc returned ore for five years, total 199 tons of lead-ore; the maximum output was 64 tons (1864).

PWLL ROMAN.

(6-in. Sheet, Card. 3 N.E.)

This name is applied on the 6-in. map to the shaft sunk in the Gwestyn shales between the edge of the marsh and the main road near the north end of Taliesin village. A. Francis, however, refers to it as Pwll Roman, or Dolelettwr, which, according to the returns in the Mineral Statistics, is the same as the Llaihvir mine, about a quarter of a mile to the north.

Output.

Only two tons of lead-ore were returned from it in 1856.

SILVER STREAM, NANTYRARIAN, OR BLAENDYFFRYN.

(6-in. Sheet, Card. 7 S.W.)

Under these names is known the group of shafts and adits near the Nantyrarian stream, about a mile east of Goginan. Two east-and-west lodes are said to occur there, among the pale mudstones, which characterise the lower part of the Frongoch formation in this district.

The Blaendyffryn shaft is sunk to the north lode, and about 200 yds. to the south-east another shaft goes down on the south lode.

Output.

The only return of lead-ore was 9 tons in 1882.

SWYDDFFYNON.

A return of 4 tons of lead-ore in 1864 under this name appears to refer to some unidentified mine west of Strata Florida station.

TALIESIN.

(6-in. Sheet, Card. 3 N.E.)

In 1854-6 and 1867, returns of lead-ore were made under this name. This ore may have been derived from Llancynfelyn, or from the shafts in the Gwestyn shales near the road, but more probably from the workings which have been described on p. 131 under Brynarian.

Output.

The total amount returned was 245 tons of lead-ore; the maximum amount was 142 tons (1855).

TEMPLE.

(6-in. Sheet, Card. 7 S.E.)

From the Rheidol gorge west of Ysbytty Cynfyn adits have been driven on a lode which ranges parallel to, and about 50 yds. south of, the Castell lode. It dips steeply to the south and has a downthrow of about 25 ft. The lode-matter on the dumps consists of brecciated mudstones with abundant quartz and considerable quantities of blende, in association with galena: it

looks promising material, but only 3 tons of lead-ore were returned (1887).

THOMAS UNITED.

This name appears to refer to S. Daren, which was worked at one time by a Mr. T. P. Thomas. It returned 75 tons of lead-ore in 1855 and 1856.

TYLLWYD.

(6-in. Sheet, Card. 7 S.W., Long. $3^{\circ} 54' 55''$, Lat. $52^{\circ} 23' 55''$.)

This small mine adjoins Gelli'reirin on the west, and lies about 200 yards north of the road in the Rheidol valley. The main lode is nearly vertical and ranges east-north-east up the steep slope of the valley. On it several old adits have been driven at various levels; the deep adit (about 230 O.D.) is at the base of the hill, but its length is unknown. Near the adit-mouth a vertical shaft has been sunk to a depth of at least 10 fms. below the adit. Francis (p. 78) states that the main lode at the shaft is joined by another, which is possibly the Bwadrain or "stag" lode.

Output.

Lead-ore was returned for 9 years after 1845; the total output was 147 tons and the greatest output 45 tons (1856). It is probable, however, that the upper levels, which seem to have been richer than the lower, were worked prior to 1845.

YNYS OR YNYSTUDUR.

(6-in. Sheet, Card. 2 S.W., Long. $3^{\circ} 56' 40''$, Lat. $52^{\circ} 31' 15''$.)

This is a small exploration by the side of an old road, $1\frac{1}{4}$ miles north-east of Treddol, on a lode traversing the upper beds of the Van formation; the lode appears to range east-north-east.

Output.

Lead-ore was returned for two years only; the total output was 9 tons.

YSTRAD EINION.

(6-inch sheet, Card. 2 S.W., Long. $3^{\circ} 54' 20''$, Lat. $52^{\circ} 31' 35''$.)

This mine lies on the west slope of the Einion valley, Glan-dovey, about 2 miles from the main road from Aberystwyth to Machynlleth. The lode ranges N.W.-S.E., through mudstones, which occupy a low horizon in the Van formation; it yielded mainly copper-pyrite in association with galena, blende, calcite and chalybite. The adit (about 590 O.D.) drains the mine to a depth of about 30 fms. The shaft, according to A. Francis (p. 1), has been sunk to a depth of 50 fms. below the adit.

Output.

The mine had been worked for a considerable period prior to 1845; the subsequent output has been galena, 9 tons; blende, 10 tons; copper-ore, 45 tons.

SUNDRY MINES.

Parcels of lead-ore from various small mines (not enumerated) were returned in 1867-70, 1872-4, 1879, 1880. The total amount is 744 tons.

CHAPTER VI.

DETAILED DESCRIPTION OF THE MINES (*continued*).MONTGOMERYSHIRE MINES WITH A TOTAL
OUTPUT OF ABOUT 1,000 TONS OR OVER.

CAE CONROY OR TYISAF.

(6-in. Sheet, Mont. 34 N.W., Long. 3° 39' 25", Lat. 52° 34' 5".)

This mine is near Tyisaf farm in the Twymyn valley, 2 miles south of Llanbrynmair village and about 4 miles by road from Llanbrynmair station (Cambrian Railway). The mine lies in the Gwestyn shales, which are brought up to the surface along an anticline, the axis of which passes through the eastern end of the workings. On the east the shales are thrown against a high horizon in the Frongoch formation by a strike-fault, which follows the Twymyn valley. The lode strikes east-and-west and dips to the north at 70° to 75°; a vertical engine-shaft reaches it at a depth of about 65 fms. from the surface, or 50 fms below an adit (about 510 O.D.), which has been driven southward from the stream east of the dressing-floors.

The adit, 10-, 20-, 30-, 40-, and 50-fm. levels have been extended mainly to the west for distances of from 30 to 120 fms. At the east end of the mine all the levels, down to 30 fms., terminate at about 25 fms. from the shaft, though they appear to be in ore up to that point. The bunches are distributed irregularly. Although only lead-ore was worked, the dumps contain a good deal of blende.

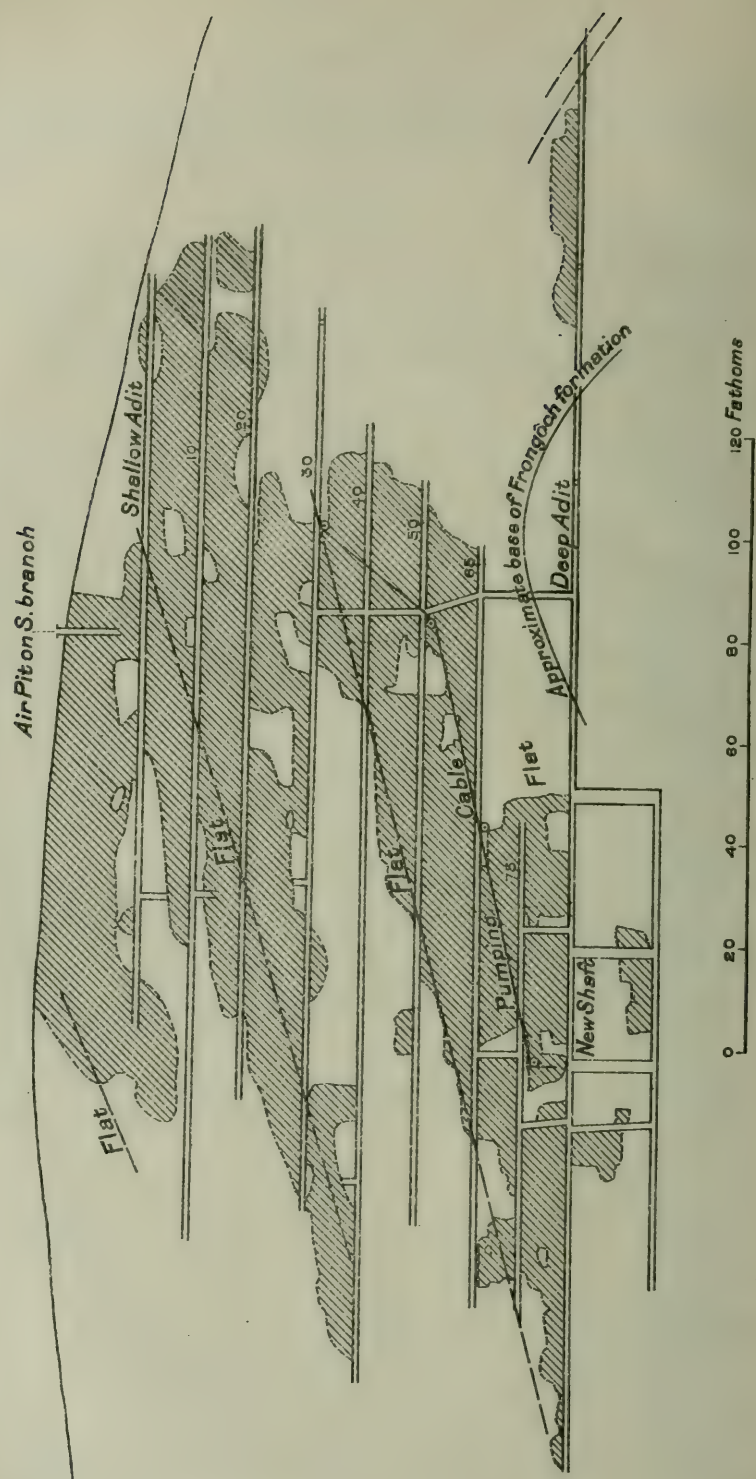
The lode is supposed to range westward towards Craiggoch and the Ceulan valley, and was intersected in Lloyd's adit 300 yards west of the engine-shaft.

Output.

The mine has returned ore in the years 1845-57, 1859-68, 1871, 1873.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 1,774	Tons. 1,301	% 73·3	Oz. 8,440 ¹	Oz. 9·7	Oz. 12·5

¹ The amount of silver in the whole of the lead-ore may be estimated at 16,728 oz.



LONGITUDINAL SECTION OF LLANERCHYRAUR.

LLANERCHYRAUR.

(6-in. Sheet, Mont. 34 N.W., Long. $3^{\circ} 40' 0''$, Lat. $52^{\circ} 34' 5''$.)

Llanerchyrour, which is also known as Tyisaf, lies on the hill of that name, about $\frac{3}{4}$ mile west of Cae Conroy. The adjoining rocks belong to the lower part of the Frongoch formation, but in the Ceulan valley to the south the Gwestyn shales are brought to the surface along a sharp anticline.

The workings lie almost wholly to the west of the anticlinal axis, and neither the main lode nor its branches have been found in a productive form to the east. They are of considerable extent, and were carried out mainly from adit cross-cuts driven southward from the steep slope of the Cae Conroy valley. The levels are reckoned from the shallow adit (about 1,220 O.D.); they are the 10, 20, 30 or middle adit (about 1,010 O.D.), 40, 50, 65, 75, 85 or deep adit (about 720 O.D.) and 100 fms. From the deep adit the new shaft was sunk to a depth of 15 fms.; the water was pumped by means of a rope and pulleys, which were carried down through the old workings from the middle adit or 30-fm. level, and operated by the large wheel at Tyisaf farm, $\frac{3}{4}$ mile to the east.

As previously described (p. 36), the main lode of Llanerchyrour gives off, near the summit of the hill, two branches which range a few degrees east of south. The western branch is comparatively unimportant, but has been worked from the surface down to the 50-fm. level; there is an air-shaft on it 120 yards north-east of the trigonometrical station (1427). The eastern branch has yielded most of the ore; its junction with the main lode can be traced in many of the deeper levels, and appears to coincide with the most continuous mass of ore. The form of the ore-body in relation to the nature and structure of the country rocks is instructive. As stated previously, the workings lie almost wholly on the west flank of an anticline which is fully exposed in the Ceulan valley to the south. There the rocks dip to the west at about 24° , and the base of the Frongoch formation is about 700 ft. above Ordnance Datum; at the mine, the Gwestyn rocks may, therefore, be expected to occur at about the level of the deep adit. In the neighbourhood of the point where it enters the lode, that adit was barren of ore, but it was productive on the west and yielded some ore, also, on the east. Apart from the continuous shoot near the junction of the lodes, the ore-body is distinctly stratiform, and consists of three layers dipping to the west at an average of about 20° , separated from one another by a barren zone; each layer appears to tail out westwards (Pl. XX.). On the longitudinal section of the mine, some structures called flats are indicated at various levels; they traverse the workings from one end to the other and dip to the west at 15° to 20° , in the same direction and at about the same angle as the adjoining rocks. They are probably either well-defined bedding-planes, or bands of shale such as occur at

intervals near the base of the Frongoch formation. There is no doubt that, in this mine, the form of the ore-body shows a striking correspondence with the dip of the rocks adjoining the lode and the comparative failure of the lode in the deep adit, and the level 15 fms. below it, seems to be related to the entry into the bottom of the mine of the Gwestyn formation. It is not impossible, however, that the barrenness of the mine at that level is local, like the barren zones at higher levels, and that if the workings had been carried down into the heart of the Gwestyn shales, where the rocks are harder, other ore-bodies might have been discovered. It is in favour of this possibility that the Cae Conroy mine worked considerable deposits of galena in the lower part of these shales; on the other hand, there is little evidence of the continuity downwards of the main ore-shoot which lies near the junction of the lodes, and in the upper levels connects the stratiform bodies.

Output.

This mine returned lead-ore in the years 1852-73, 1875-7, 1879-81, the maximum output being 1,135 tons in 1869.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons.	Tons.	%	Oz.	Oz.	Oz.
7,198	5,493	76	36,423 ¹	5·6	7·3

The yield in the lower part of the mine is stated on the plan to have been from 10 to 35 cwt. per fathom (probably per fathom of driving). The stoped area is about 10,000 sq. fms., which indicates an average yield of recovered ore throughout the mine, of at least 14 cwt. per sq. fathom.

RHOSWYDOL.

(6-in. Sheet, Mont. 33 N.W., Long. 3° 42' 50", Lat. 52° 33' 45".)

The dressing-floors of this mine lie in the valley about 2 miles east of Aberhosan, and about 7 miles by road from Machynlleth.

The workings are mainly on Banc Rhoswydol about half a mile to the east. At one period a discovery of lead-ore at Bwlch coch by the side of the old Machynlleth-Llanidloes road, and a quarter of a mile south of the dressing-floors, was worked under the name of Bacheiddon in conjunction with Rhoswydol. The lode on Banc Rhoswydol was worked from several shallow

¹ The amount of silver contained in the whole of the lead-ore may be estimated at 40,203 oz.

adits and a shaft near the base of the hill. In addition to the main lode which ranges west-south-west and dips south at 55° to 65° , there is also a north lode about 80 yds. to the north, and a nearly vertical cross-lode which strikes west-north-west out of the main lode near the shaft. From the valley near the dressing-floors an adit (about 650 O.D.) has been driven eastward towards the workings on the south lode, and another (about 720 O.D.) on what is probably the north lode. It is not known how far these levels extend, as no plan of the workings has been seen.

On most of the dumps, especially those on Banc Rhoswydol, there is a considerable amount of blende, some of it in globular masses with a radiating fibrous structure.

The Bwlch coch or Bacheiddon lode is only known in that locality; it ranges about west-north-west, in the direction of the prevailing joints; the ore-body had the form of a disc or lenticle, about 50 fms. in length, and is said to have been very rich. It was worked mainly from an adit cross-cut (about 1,000 O.D.), driven in from the north; at a later period a deep adit cross-cut (about 750 O.D.) was made, but at this level the lode was all but barren. The lenticle was worked away in a few years.

Output.

Rhoswydol returned lead-ore in the years 1846-63, 1868-71, 1873-77. Bacheiddon was working between 1855 and 1860.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 3,984	Tons. 3,022	% 75	Oz. 4,560 ¹	Oz. 3·2	Oz. 4·3

Bacheiddon probably yielded about 1,000 tons out of the total amount of lead-ore given above.

CWMBYR.

(6-in. Sheet, Mont. 33 S.W., Long. $3^{\circ} 47' 20''$, Lat. $52^{\circ} 32' 10''$.)

Cwmybyr lies at the head of a ravine which leads into Afon Hengwm, about 1 mile south-west of Aberhosan. It is 7 or 8 miles distant from Machynlleth railway-station and for about 3 miles the road is poor and narrow. The lode does not appear to have been met elsewhere. No plans have been seen and nothing is known of the extent of the workings.

¹ The amount of silver in the whole of the lead-ore may be estimated at 12,570 oz.

Output.

Returns of lead-ore were made in the years 1863-5, 1868, 1869, 1871, 1873-7.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 497	Tons. 376	% 75	Oz. 218 ¹	Oz. 2·4	Oz. 3

Blende.—731 tons.

DYLIFE.

(6-in. Sheet, Mont. 33 S.E., Long. 3° 40' 50", Lat. 52° 31' 55".)

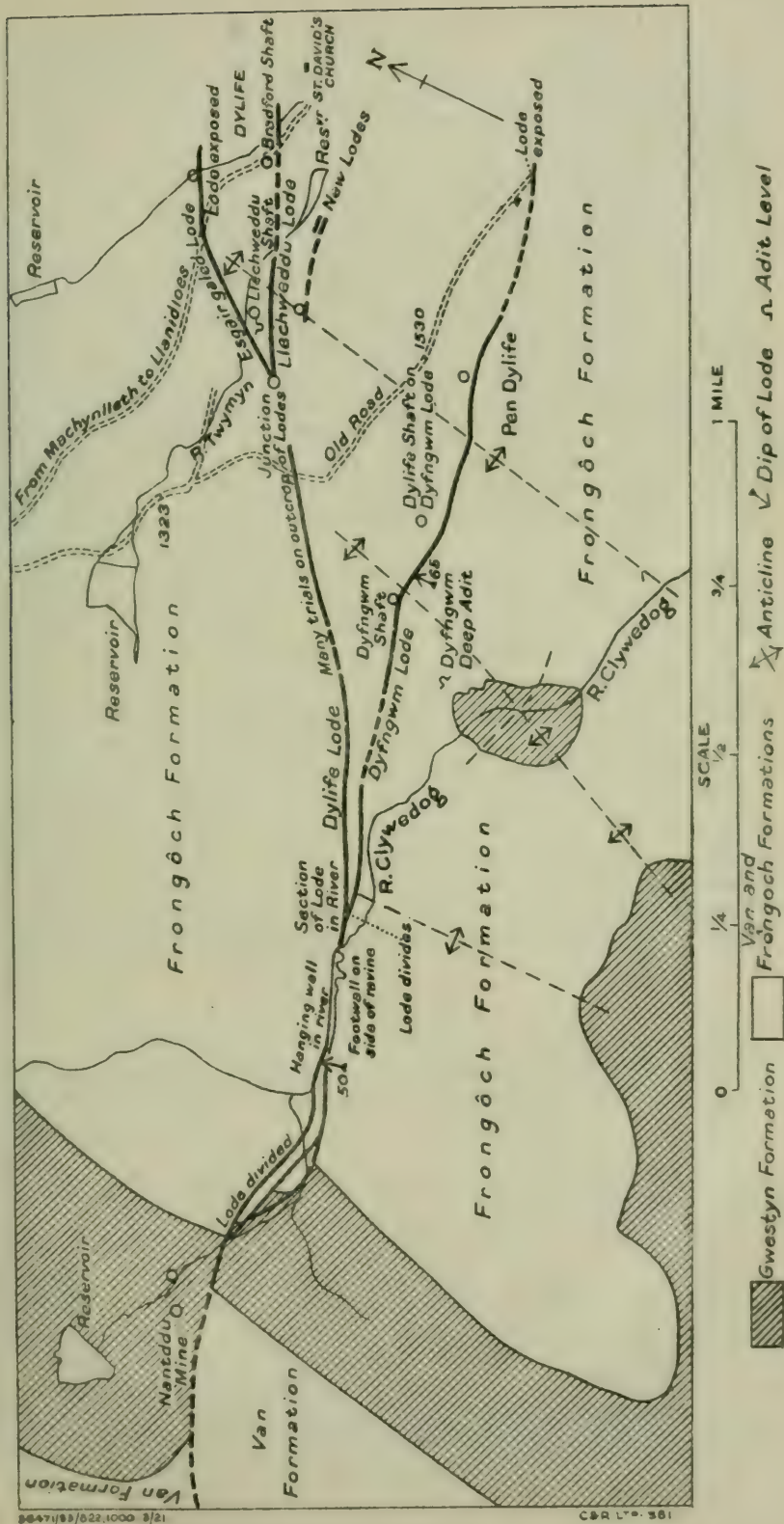
This mine lies in the centre of an elevated plateau about midway between Machynlleth and Llanidloes, and on the old hill-road connecting these two places. The nearest station is Llanbrynmair, to which the distance by road is about 9 miles.

Three lodes have been worked and the workings on them appear to be in the main distinct. Unfortunately no plan is available, and the information has been obtained verbally from miners who have worked in the mine. The main workings were on the Llechwedd ddu lode, which dips to the north at about 75° to 80°, and were carried on from two shafts. The Llechwedd ddu or western shaft is situated in the valley opposite the row of cottages called Rhanc y mynydd; it was sunk vertically to the lode for 50 fms., and was then continued as an underlie shaft to the 100-fm. level. The Bradford or eastern shaft is 380 yds. east-north-east; it was sunk to the 130-fm. level, and from this level a winze was carried to a further depth of 25 fms. The 120-fm. level has been extended under the western shaft. Towards the east the workings are said to reach about opposite to the church, 300 yds. east of the Bradford shaft.

The western shaft is 50 yds. to the west of a strong anticlinal axis which ranges north-and-south (Pl. XXI.). The beds in the flank of the anticline dip at 35° to 40°. In the crest of the anticline and near the shaft a characteristic group of pale-green mudstones is exposed; these lie in the lower part of the Frongoch formation, and at a distance above the base which can be determined within narrow limits. It is probable that the Llechwedd ddu shaft passed through this formation into the Gwestyn shales at a depth of about 80 fms., but in the eastern or Bradford shaft those shales are probably at a depth of about 150 fms., or approximately at the level of the winze from the bottom of the workings.

It is interesting to find that the débris lying on the surface near the eastern shaft, and apparently derived from the last workings, consist of the uppermost beds of the Gwestyn shales. Similar material near the western shaft is said to have come from

¹ The amount of silver contained in the whole of the lead-ore may be estimated at 1 160 oz.



GEOLOGICAL MAP OF DYLFIE AND DYFNOWM DISTRICTS.

the 90-fm. level, and thus agrees with the conclusion drawn from the examination of the surface. Another interesting feature is the occurrence of large calcareous nodules such as are commonly found in association with the upper beds of the Gwestyn formation. There are said to have been met in driving east and west at the 70- and 80-fm. level from the western shaft. It appears, therefore, that the main ore-body of Dylife lay in the lower part of the Frongoch beds, and that the bottom of the mine coincides approximately with the base of that formation. It is significant, too, that the workings were carried to a greater depth in the eastern shaft, where the Frongoch rocks are considerably deeper than they are in the western shaft. Although some ore appears to have been found within the underlying Gwestyn shales, near the west end of the mine, it is clear that the bulk of it was obtained at a higher level. The richest ore is said to have occurred about half-way between the two shafts and about the 40-fm. level; the lode was there crossed by a soft joint dipping steeply to the west, and was much enriched in its neighbourhood.

The workings on the northern or Pencerig lode were carried out from a shaft sunk vertically to the lode to a depth of about 40 fms. This shaft is 200 yds. north-west of the Bradford shaft. The lode is from 14 to 15 yds. wide, and although it yielded a payable amount of lead-ore near the surface, the lower levels of the mine yielded blende only and the workings were not prosecuted further for this reason.

The southern or Dyfngwn lode lies about one-third of a mile south of Dylife and is reached by an adit cross-cut (about 1,240 O.D.), which was driven from a point near the Llechwedd ddu shaft under Pen Dylife; there a shaft was sunk to a depth of 30 fms. below the adit. Nothing is known about the extent of these workings or their yield. They communicate with the Dyfngwm workings on the west, the adit at Dylife being about 10 fms. below the Dyfngwm adit.

Output.

In some years the returns for Dylife appear under Blaen Twymyn. Lead-ore was returned in the years 1845-62, 1864-84, 1887-93, 1899-1901. The greatest output was 2,571 tons in 1862.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 35,505	Tons. 26,498	% 74·6	Oz. 126,286 ¹	Oz. 4·4	Oz. 5·8

Blende.—391 tons.

Copper-ore.—1,342 tons.

¹ The amount of silver contained in the whole of the ore may be estimated at 154,160 oz.

DYFNGWM.

(6-in. Sheet, Mont. 33 S.E., Long. 3° 41' 45", Lat. 52° 31' 25".)

This mine is near the deep ravine through which the upper part of the River Clywedog flows, and about one mile south-west of Dylife. It is somewhat inaccessible and the ore had to be taken either to Machynlleth by the old and difficult hill-road or 10 miles to Llanbrynmair station.

The workings lie on the southern or Dyfngwm branch of the Dylife-Dyfngwm lode-belt (*see* Pl. XXI.). The early workings were carried out from a shaft 250 yds. west of the Pen Dylife shaft on the same lode, but at a later period a deep adit (about 1,310 O.D.) was driven from the side of the valley northward into the lode. The bottom of the shaft is about 40 fms. below the adit. The lode carries galena and blende, and it appears that the proportion of blende was greater at and below the level of the adit than nearer the surface. The shaft has been sunk a little to the east of an anticlinal axis along which the Gwestyn shales outcrop in the valley, and the rocks at the surface are pale-green mudstones similar to those at the western shaft at Dylife. The workings lie, therefore, within the lower part of the Frongoch formation, but the bottom of the mine probably enters the underlying Gwestyn shales.

The mouth of the deep adit is about 50 ft. above the base of the Frongoch formation, but, as the rocks have a slight northerly dip, this distance is increased in that direction, and the base of the formation is carried down still farther by a northerly downthrow which occurs at the lode. The relation of the ore-body to the country-rocks is, therefore, similar to that which obtains at Dylife.

It is interesting to observe also that the lode in both these mines carries a considerable proportion of copper-ore; this is a common characteristic of lodes in the neighbourhood of the Gwestyn shales though it is not confined to them.

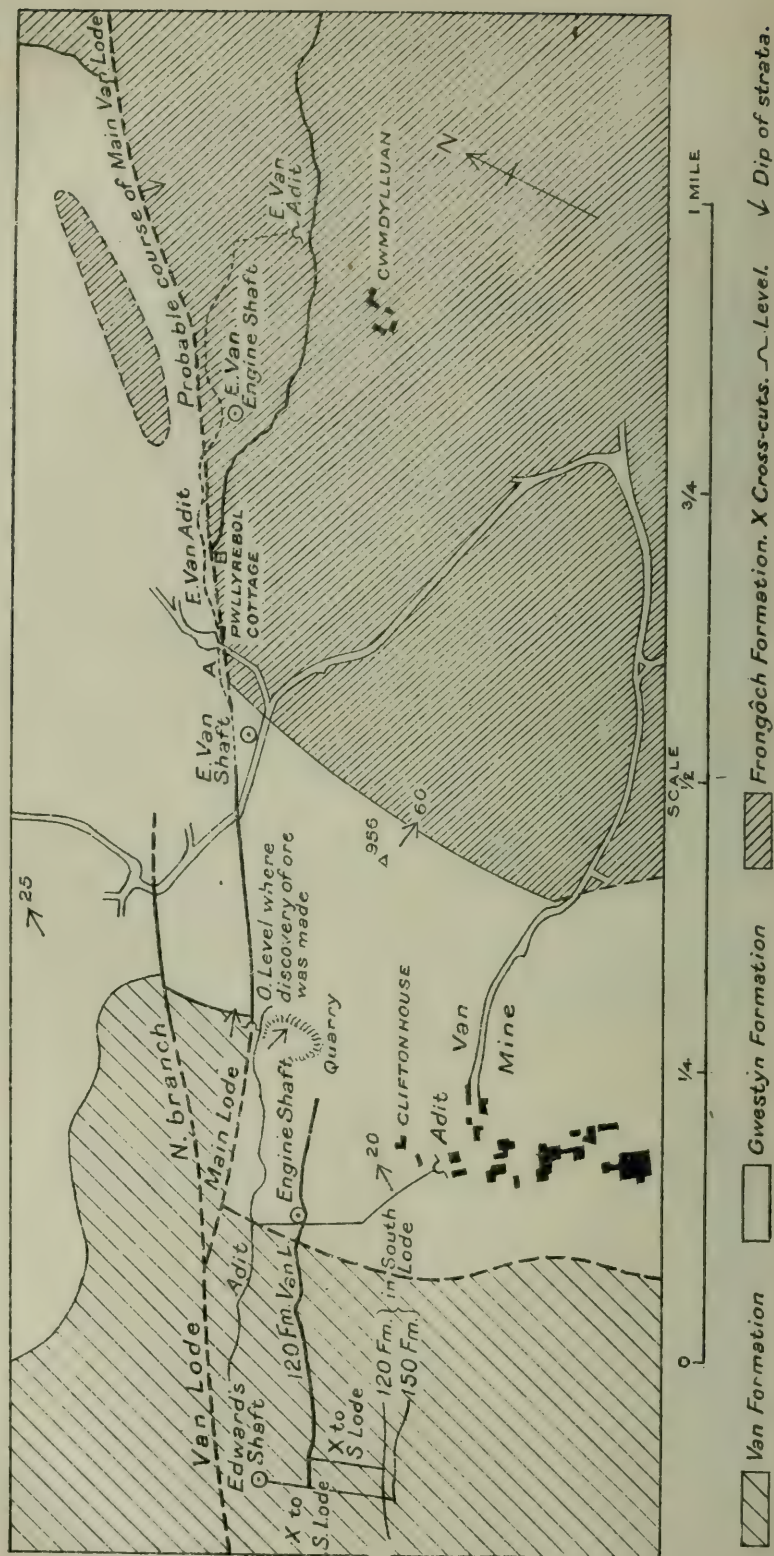
Output.

Lead-ore was returned in the years 1845, 1847-49 and 1852-70. The greatest output was 541 tons in 1862.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 4,930	Tons. 3,797	° 77	Oz. 10,356 ¹	Oz. 2·4	Oz. 3·1

Copper-ore.—134 tons.

¹ The amount of silver contained in the whole of the ore may be estimated at 11,798 oz.



GEOLOGICAL MAP OF DISTRICT NEAR VAN MINE.

VAN.

(6-in. Sheet, Mont. 41 S.E., Long. $3^{\circ} 33' 30''$, Lat. $52^{\circ} 28' 40''$.)

Van has been the most productive mine in the district; it lies on the lode of the same name, about $2\frac{1}{2}$ miles north-north-west of the town of Llanidloes and about 3 miles from the station. The mine is served by a branch line of normal gauge about 6 miles in length which, following the Ceryst valley, joins the Cambrian railway at Caersws. The workings are mainly in the upper part of the Van formation.

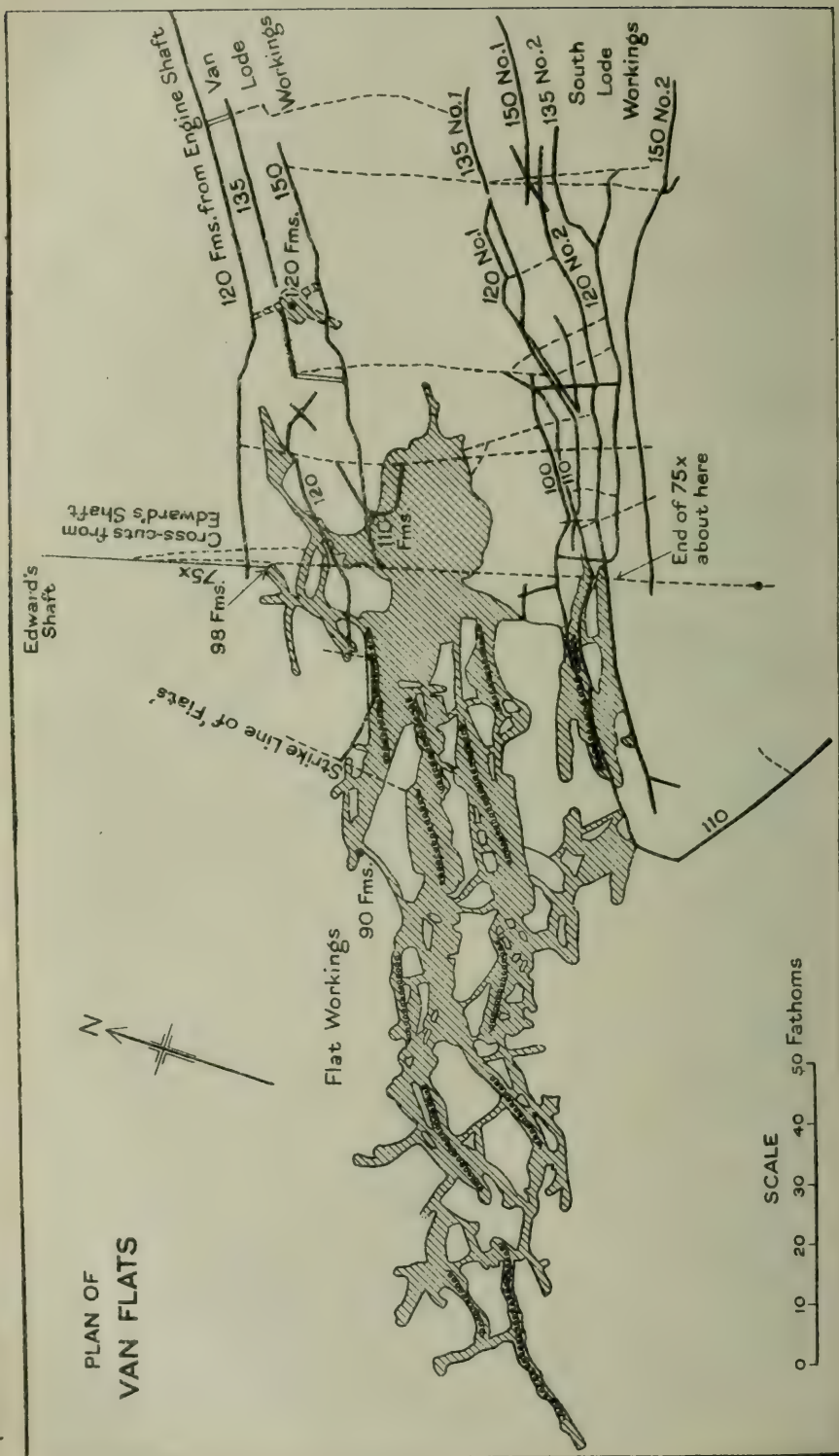
Previous to 1850 the most easterly mine on the Van lode was Penyclun, but about that year search was made for the extension of the lode eastward. After four years' exploration the lode was discovered at the surface near the site of the large quarry which was subsequently opened east of the mine, and, in view of the obvious surface-feature made by the lode it is surprising that this discovery was not made earlier. From this point an adit was driven eastward on the lode, but eight years elapsed before any ore was found in a winze which was sunk below the level. The ore was not in payable quantity, and, owing to difficulty with water, the manager continued a cross-cut which had been begun some years previously. This is now the adit (about 710 O.D.) of the mine. After driving about 75 fms., a rich lode was intersected at a depth of about 30 fms. from the surface. This was 15 years after the prospecting for the lode had commenced. The mine was then floated as a company with 12,000 shares at 4*l.* 5*s.* per share. The lode proved so productive that in less than five years afterwards the shares were quoted at 84*l.* each. In subsequent years, owing to an increase in the capital, the market-value of the shares declined.¹

The workings were carried out mainly from the present engine-shaft (about 120 fms. below the adit) (Pl. XXII.). Edwards' shaft, which was sunk 400 yds. west of the engine-shaft to a depth of 150 fms. below the adit, was intended to serve as a pumping-shaft and also for working the ore in the western end of the mine, but was never used for the latter purpose. The shaft is vertical and intersects the lode at about the 45-fm. level; below this point the lode is south of the shaft and is reached by cross-cuts, increasing in length as the lode becomes deeper. About 40 fms. east of the cross-cut south from Edwards' shaft at the 120-fm. level, the workings entered a body of ore which has since been proved to be different from that of the Van lode, and is known as "flats." Other cross-cuts to the south between the 100- and 150-fm. levels reached a third body of ore forming what is called the south lode. The ore from all these workings was drawn along the 120-fm. level to the engine-shaft, and from that through the adit to the dressing-floors.

¹ Ed. Hamer, A parochial account of Llanidloes, pt. 1, 1873, pt. 2, 1876, Lond.

As described previously (p. 41), the lode is extremely wide, and a method of working had to be devised for the safe removal of the wide mass of almost pure galena which occurred in many parts of the mine. This method is fully described by Le Neve Foster (*Trans. Royal Geol. Soc., Cornwall*, 1879), who also gives a longitudinal section which indicates that at that time the engine-shaft had reached its present depth, and that the lode had been largely stoped away to the 60-fm. level and partly stoped to the 105-fm. level. The method adopted was as follows:—A cross-cut was driven from the engine-shaft into the lode; when the cross-cut reached the south part of the lode or “flucan” a level was started in it to the east and another to the west. Cross-cuts were then driven out through the lode about 20 to 30 fathoms apart and from these a level in the lode, generally close to the footwall, was extended east and west. In the next stage the lode in this level, as far as the footwall in the north and as far as its productive limit on the south, was stripped down and the empty spaces packed with “deads” derived from the “flucan” and from the poor parts of the lode, and, if these did not suffice, further supplies were drawn from workings in dead ground at higher levels, or brought in from a quarry at the surface. In the midst of the deads a working-level was preserved and secured with timber. When this was complete the level in the flucan was generally abandoned. In the meantime, winzes were sunk from the level above at 20 or 30 fathoms apart, usually in the flucan, but sometimes in the lode itself. These winzes served for ventilation, and also as shoots or passes for rubbish used in filling up any excavation. As soon as these arrangements for ventilation and for filling up were completed, stoping was commenced and, as each stope was worked out, the excavation was carefully packed with rubbish of which the lode itself furnished about one-third. A large amount of filling was derived from slate quarried at the surface and trammed to the mine; through the filling the winzes or passes were kept open. Before removing the few feet of lode which remained below the workings of the level above, the stopes were packed up tightly with rubbish, and the ore removed by driving a fresh level east and west in the middle of the lode and packing up the empty spaces. The block of lode 15 fms. high was thus removed entirely, and its place filled with rubbish. This system saved a large expenditure on timbering, and proved to be almost indispensable.

The lode east of the shaft at the 120-fm. level strikes more nearly east-and-west than in the main part of the mine (*see* p. 41), and blende becomes relatively more abundant than galena; at the surface this change of strike occurs considerably farther west. Where it takes place there is evidence, both at the surface and at the 120-fm. level, that a branch has sprung off, the direction of which is continuous with the main lode west of the junction. It can be demonstrated, however, by mapping, that the displacement of the rocks along this branch is a few feet



PLAN OF VAN FLATS.

only, whereas the main lode, which at that point carries blende, is a downthrow to the south of 200 to 250 yds. The relation of the main lode and the branch are indicated in the sketch-map (Pl. XXII.). The inclination of the lode throughout most of the workings averages about 64° , but east of the engine-shaft it appears to be about 70° .

The workings on the south lode lie mainly between the 100- and 150-fm. levels. The lode is parallel with the Van lode but dips to the south at an average inclination of about 74° . The two lodes, therefore, tend to approach one another in depth but their junction is probably about 600 fms. below the surface. The south lode is bounded mainly by grits similar to those in which the flats are situated, and in places the lode proved to be exceedingly rich. In the 110-fm. level, both on the north and on the south, the grits dip towards the lode, which is, therefore, a fracture along the axis of a shallow syncline. The 110-fm. cross-cut was continued southward for 30 fms. beyond this lode. At the end of a cross-cut from the 150-fm. level, 18 fms. south of the south lode, a bore-hole was put down to a depth of 1,100 ft., but apparently no discovery of ore was made in either case.

"The Flats."—The workings described as the "flats" were first entered at the 120-fm. level, some distance east of the cross-cut from Edwards' shaft, but the main body of ore was discovered farther west and at higher levels (Pl. XXIII.). This ore was found to extend for a width of 40 to 50 fms. from north to south, but was confined within a vertical depth of 6 to 7 yds., and was bounded by massive rock which was in some places much fissured and in other places brecciated. The body of ore appears, therefore, to be limited both upwards and downwards. It was found, however, on prosecuting the workings westward that the base and top of the flats rose gradually in that direction. It was for a time believed that this unusual occurrence indicated that the main or Van lode had there assumed an almost horizontal position. The examination of the mine underground in connection with the present survey revealed the true nature of these ore-occurrences. The flats lie within a group of massive grit-beds which underlie the Upper Van mudstones, and the upper and lower boundaries of the flats coincide approximately with the boundaries of this grit-group. A comparison of the position of these grits with the surface-geology proved that they are the same beds as are exposed on the road west of Penyclun farm three-quarters of a mile west of the point where they were first met underground. The average inclination thus indicated is 15° , which is in approximate agreement with the observations made in the workings.

The main "makes" of ore are found to be in vertical fractures which range approximately parallel with the Van and south lodes. Subsidiary makes are occasionally found along the base of the flats and along other fissures trending in other directions.

The mode of occurrence is not unlike that which is characteristic of ore-bodies in limestone, except that the fissures in these grits have not been enlarged by solution subsequent to their formation. Another characteristic of these makes is that they are comparatively short in the direction of their strike, and when one dies out its place is usually taken by another lying somewhat to the north or to the south. In some parts of the workings there may be three or four of these side by side and separated from one another by 4 to 6 fms. In going westward the base and top of each make rises in conformity with the dip of the grit-group; their number and richness tend to diminish also in that direction, though there is no doubt that the rocks in which they occur rise to the surface. As seen in plan the makes taper at both ends, and it is usually found that as the fissure diminishes in width the place of galena is taken by blende so that at the extremities of the fissures that mineral alone remains. A considerable proportion of the output of the mine during the last 20 years appears to have been derived from these flats.

According to the longitudinal section which is preserved at the mine, the ore-body in the main or Van lode forms a shoot with an average inclination of 30° to 40° from the horizontal and with fairly-defined upper and lower limits. The richest part of the mine appears to have been in the neighbourhood of the 60-fm. level, where the shoot had a length of about 150 fms. Below the 120-fm. level, comparatively little payable ore was found. At the east end of the mine, galena gives place to blende in most of the levels, and east of the engine-shaft a considerable proportion of the lode carrying a mixture of galena and blende, and forming the eastern limit of the shoot, has not yet been worked away.

It is interesting to note that the centre line or axis of the shoot extends in depth towards the point where the ore in the flat commences, and also towards the locality where the south lode was productive. It is difficult to resist the impression that the ore of the flats and that of the lode has a common origin at a greater depth, possibly near the point of junction of the south and Van lodes.

Output.

Ore was returned in the years 1866-92, 1894-1917. The greatest output was 6,850 tons of lead-ore in 1876.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 96,739	Tons. 75,400	% 77.9	Oz. 756,142 ¹	Oz. 7.8	Oz. 10.3

Blende, 28,424 tons.

¹ The amount of silver contained in the whole of the lead-ore may be estimated at 771,557 oz.

PENYCLUN, OR PENCLUN.

(6-in. Sheet, Mont. 41 S.E., Long. 3° 34' 20", Lat. 52° 28' 30".)

This mine is called after a farm about 3 miles north-west of Llanidloes. According to Edward Hamer,¹ lead-ore was first discovered about the year 1845 and, until the discovery of ore at the Van, it was the eastern known limit of the Van lode. The mine appears to have been worked in some years independently, and in other years in connection with Bryntail, which lies on the same lode to the west. There are no plans of the underground workings available, and no substantial information as to their extent or character is procurable. It appears, from the excavations at the surface west of the farm, that the main ore-body was found on the south side of the lode, and possibly on a branch. An adit cross-cut (about 760 O.D.), which was driven in from the edge of the valley south of the farm, drained the workings to a depth of about 40 fms. At a later period, another adit (about 620 O.D.) was made about 300 yds. east of the farm; it was from this adit that most of the later workings were carried out.

The rocks in the hanging-wall of the lode at the surface consist of the Upper Van mudstones, but the grits which underlie them outcrop near the western limit of the property, and descend thence with an average dip of about 15° towards the bottom of the Van mine on the east; they must, therefore, underlie the Penyclun mine at a smaller depth than at Van. It is not known, however, whether these grits carry ore in Penyclun corresponding to that in the Van flats. The material on the waste-heaps consists mainly of mudstones, but a considerable proportion of grits also occurs, and it is possible that lead-ore has been found in them. In this mine galena was associated with a considerable amount of barytes, but the relation of the minerals to one another is not known.

Output.

Where separate returns are available, they are so indicated; but during certain years the mine was held jointly with Bryntail under the name of Van Consols, the returns from which are appended.

Penyclun.—Lead-ore was returned in the years 1849–1851, 1853, 1857, 1859, 1861, 1864–1866, 1872. The greatest output was 776 tons in 1850.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons.	Tons.	%	Oz.	Oz.	Oz.
1,805	1,112	61·6	405 ²	2·7	3·7

¹ *Cit. supra.*

² The amount of silver contained in the whole of the ore may be estimated at 4,451 oz.

Van Consols.—Lead-ore was returned in the years 1871, 1873–1883. The greatest output was 283 tons in 1882.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 1,661	Tons. 1,262	% 76	Oz. 2,864 ¹	Oz. 3·2	Oz. 4·2

Barytes, 862 tons.

BRYNTAIL.

(6-in. Sheet, Mont. 41 S.E., Long. 3° 35' 35", Lat. 52° 28' 10".)

This property extends on the Van lode for a distance of nearly 1,000 yds., and is bounded westward by the deep valley of the River Clywedog. Between Bryntail and Penyclun on the east is a small trial on the same lode known as the Glyn mine, which has usually been held with Bryntail. The mine is about 3 miles by road from Llanidloes station.

The workings have been carried out at two points, and at various times two distinct dressing-floors have been in use, one near the outcrop of the lode in the Clywedog valley and the other about a quarter of a mile lower down. Near the eastern end of the property around Bryntail farm, there are two shafts: one 120 yds. east of the farmhouse and the other, known as Gundry's engine-shaft, about the same distance south-west of the farm. These workings were drained by an adit (about 710 O.D.), about 450 fms. in length, which was driven eastward from the Clywedog. The eastern shaft is said to have been sunk to a depth of 60 fms. below the adit, and the western shaft about 40 fms., but little work appears to have been carried out in the deeper workings from either shaft. The ore seems to have been sparsely distributed through the lode, and to be more abundant in the upper workings than at a depth. Near the river and the mouth of the adit, the Western engine-shaft was sunk to a depth of 30 fms. below the adit, but the lode appears to have been unproductive in this locality. About 200 yds. west of Bryntail farm, a large mass of barytes was worked near the outcrop of the lode and close to the footwall. It was explored to a depth of about 20 fms., and is said to have been largely removed. This mineral occurs also in the dumps from the shaft east of the farm in association with galena and witherite. Throughout the western part of the property the rocks at the surface consist of alternating beds of grit and shale pertaining to the Lower Van formation, and are the lowest

¹ The amount of silver contained in the whole of the lead-ore may be estimated at 5,307 oz.

strata exposed in this district. In the eastern workings the rocks consist of the Upper Van mudstones, which lie in a syncline overlying the grits.

Output.

Lead-ore was returned in the years 1845–1867. The greatest output was 158 tons in 1847.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 1,821	Tons. 1,254	% 68·8	Oz. 916 ¹	Oz. 3·1	Oz. 4·1

NANTIAGO.

(6-in. Sheet, Mont. 40 S.E., Long. 3° 43' 40", Lat. 52° 27' 40".)

This mine lies near the head of one of the tributaries of the Upper Wye, at an altitude of about 1,500 ft. above sea-level. In a direct line, it is 8 miles west of Llanidloes, but the distance by road is between 12 and 13 miles.

The lode ranges a few degrees south of west through the Upper Van mudstones. The rocks are folded into a sharp anticline along a north-and-south axis, and both east and west of the mine the Van rocks are overlain by the Gwestyn shales. In the direction of the axis, and about 1,000 yds. to the north, the Lower Van grits are exposed in the crest near the old mine of Snowbrook or Nantyreira. The crest of the anticline pitches southward at about 10°, and the grits, therefore, underlie the Upper Van rocks at a moderate depth in Nantiago mine.

At Nantyreira, a strong fissure, ranging parallel with the axis of the anticline, has been worked as a lode. A similar fissure, termed a cross-course, has been met in Nantiago in the 50- and 60-fm. levels, and has also been traced at the surface for many miles both to the north and to the south (*see* page 9).

The mine is worked from a shaft which is sunk to a depth of 70 fms. below drainage-level. The adit (about 1420 O.D.) has been driven from near the stream and the dressing-floors as a cross-cut for a distance of about 65 fms., and has then been extended westward on the lode for about 160 fms. It drains the mine to a depth of about 17 fms. below the surface at the top of the shaft. Below the adit, levels at 10, 20, 30, 40, 50 and 60 fms. have been driven, mainly in a westerly direction. The longest, or 20-fm. level, extends to about 160 fms. west of the shaft. Westwards, in most of the levels, the lode shows a tendency to split up; but, generally, throughout the workings it varies from 3 to 6 ft. in width, and consists of fragments of rock cemented by calcite. In other places almost the whole fissure is filled with calcite containing blende, or a mixture of blende and galena in strings or spots. In parts of the lode large

¹ The amount of silver contained in the whole of the ore may be estimated at 5,390 oz.

vughs are commonly found; many of these are lined with calcite crystallised in low rhombohedra, which often grow together in elaborately-branched masses; but some, partially filled with calcite, are lined on the inside with crystallised blende, or show concentric growths of calcite and blende in alternate layers. To the east of the shaft the lode dips to the south at 80° to 85° , but west of that point it becomes practically vertical or may even dip slightly to the north. Still farther west, it resumes its southerly dip. In the 50- and 60-fm. levels, massive grits occur on both sides of it, and probably reach to a slightly higher level.

The cross-course or fissure mentioned above was met in the 50-fm. level 45 yds. west of the shaft. It is clearly defined and dips to the east at 75° to 80° . It has been cut through also in the 60-fm. level.

In view of the structure of the rocks adjoining the mine, the distribution of the ore is instructive. In payable quantities, it is found in a belt which takes the form of a rude arch, consisting of a shoot dipping eastward from near the shaft at an angle of about 65° , and another dipping westward at an average angle of 30° to 40° . In the upper levels near the shaft, these two bodies are continuous, but from the 30-fm. to the 50-fm. level there is a barren stretch, increasing in length downwards and lying mainly to the west of the shaft. This is a region where the grits abut on the lode, and the ore-body appears to conform very nearly to the stratification of the rocks. The payable ore has been found mainly in the mudstones immediately overlying the grits. The conditions appear, therefore, to be not unlike those in the Plynlimon mine, which is about $1\frac{1}{2}$ miles to the west and is probably on the same lode. As the grits here and elsewhere are underlain by other beds of shale, it is possible that the lode may recover itself when the hard beds have been passed through and, in fact, ore was found in the 60-fm. level at several points below the barren stretch which occurs in the overlying level, and this ore may indicate the incoming of another shoot below the grit-beds.

Output.

Returns are available for the years 1846, 1861-66, 1869, 1871-1878, 1882, 1883, 1885-1888, 1903-17. The greatest output was 176 tons of lead-ore in 1875.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 1,709	Tons. 1,292	% 75.5	Oz. 1,651 ¹	Oz. 3.6	Oz. 4.5

Blende, 1,929 tons

¹ The amount of silver contained in the whole of the ore may be estimated at 6,176 oz.

WYE VALLEY.

(6-in. Sheet, Mont. 46 N.E., Long. $3^{\circ} 43' 40''$, Lat. $52^{\circ} 26' 50''$.)

Under this name are included two mines which lie in the upper part of the Wye valley, about a mile south of Nantiago and 8 miles in a straight line west of Llanidloes, from which the distance by road is 12 miles. The upper mine is known locally as Nantygwrddy or West Nanty, and also as the Wye Valley mine. The lower is called Dolminers or West Wye Valley. It is unfortunate that no plans of these mines can be traced, especially as Dolminers appears to lie on the eastward continuation of the Castell lode of Cardiganshire, which is believed to be the same as the Van lode (*see* p. 47). East of this point, however, owing to the lack of rock-exposures, it has not been possible to prove the continuity of the lodes. The upper mine is clearly not on the main lode, but on a comparatively small branch which dips to the south at about 85° , and is visible as a mass of breccia 12 to 15 ft. wide in the Nantygwrddy ravine. The strike is east-north-east towards the Severn valley near Maesnant, where several small lodes are known. It has been worked from two shafts on the lode and drained by an adit (about 1,550 O.D.). A little to the east of these workings, a small lode ranging east-and-west, with a dip of about 70° to the south, crosses the base of the Frongoch formation, but does not appear to have been productive. Nothing is known of the underground workings on these lodes. The country-rocks are the Gwestyn shales, which are well-displayed in numerous sections near the mine.

The lower mine, or Dolminers, consists of a vertical shaft sunk in the Gwestyn shales to a depth of about 80 fms. The outcrop of the Castell lode probably lies a short distance to the north of the shaft, and the westward continuation of the Nantygwrddy branch may join the main lode at this point. It is possible, therefore, that both lodes were worked and that the ore was obtained near their junction. The mine lies near the same anticlinal axis as Nantiago and the cross-course of that mine traverses the area from north to south. About 150 yds. south of the Dolminers shaft, the base of the Frongoch formation is displaced by it in such a way as to indicate an easterly downthrow of about 30 yds.

Output.

The returns are indicated, as far as possible, under the individual headings.

Lead-ore was returned from West Nanty, Nantygwrddy or Wye valley in the years 1865, 1866, 1874-79; from West Wye valley in 1877-80; from New Wye valley in 1880-84.

—	Lead- Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.	Blende.
	Tons.	Tons ¹	%	Oz.	Oz.	Oz.	Tons.
West Nanty, Nanty- gwrdd or Wye Val- ley - - -	1,595	1,231	77	5,086 ¹	3·8	5·5	335
West Wye Valley -	360	286	79	1,372 ²	3·9	4·9	—
New Wye Valley -	309	229	74	—	—	—	111

NANTY.

(6-in. Sheet, Mont. 46 N.E. and S.E., Long. 3° 41' 15",
Lat. 52° 25' 30.)

This mine lies by the side of the main road from Aberystwyth to Llanidloes, near the ninth milestone from the latter place. It appears to have been highly productive during the comparatively short period that it was working. The lode is unusual in that it ranges nearly north-and-south, and is the only productive lode in the country which has this strike; its dip is probably at a high angle to the west. It was worked originally by several old adits, but more recently by a deep adit driven from near the River Wye (about 1,020 O.D.), and an engine-shaft on the slope above, which has been sunk to about 20 fms. below the adit. Most of the ore was found in the workings near the main road, and although the lode has been traced for over half a mile to the north, it has not been productive in that direction. It lies near the top of the Frongoch formation, and the rocks at the surface contain in places massive beds of grit.

Output.

Lead-ore was returned in the years 1856, 1861–66, 1871. The greatest output was 632 tons in 1863.

Lead- Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 1,781	Tons. 1,390	% 78	Oz. 9,482	Oz. 5·3	Oz. 6·8

BRYNPOSTEG, OR LLANIDLOES.

(6-in. Sheet, Mont. 48 N.W., Long. 3° 30' 45", Lat. 52° 25' 40".)

The workings are situated by the side of a marshy tract east of the road from Llanidloes to Tylwch, and about 2 miles

¹ Silver contained in the whole of the ore estimated at 6,450 oz.

² " " " " " " 1,400 oz.

south-east of the former place, but the adit (about 890 O.D.) which drains the mine to a depth of 25 to 30 fms., has been driven from the dingle below Brynposteg farm on the west side of the road. The lode ranges a few degrees south of east, and dips to the south at 75° to 80° ; it traverses rocks which belong to a high horizon in the Frongoch formation. The engine-shaft is sunk to a depth of 84 fms. below the adit, and levels have been driven at 12-fm. intervals. The 12-, 24-, 36- and 48-fm. levels are each about 90 fms. in length; the others are from 20 to 30 fms. There is an old shaft to the adit, about 60 fms. west of the engine-shaft; and another about 125 fms. to the east. The adit has been extended about 30 fms. beyond the latter.

It is said that great difficulty was experienced in coping with water; this may possibly have been drawn from the adjoining marshy tract.

It would appear from the plan and section preserved in the Home Office, that the ore formed a shoot dipping to the east; considering the relatively small extent of the workings, the lode at this spot must have been fairly rich.

Output.

There are returns from this mine in 1855, 1868-70, 1875-78.

Lead-Ore.	Lead.	Ratio.
Tons. 614	Tons. 456	$\frac{\circ}{\%}$ 74

Blende, 353 tons.

CHAPTER VII.

DETAILED DESCRIPTION OF THE MINES—(*continued*).

NOTES ON MONTGOMERYSHIRE MINES WITH A TOTAL OUTPUT OF LESS THAN 1,000 TONS.

(These mines are arranged in alphabetical order.)

ABERDAUNANT.

(6-in. Sheet, Mont. 41 S.W. & S.E., Long. $3^{\circ} 36' 35''$,
Lat. $52^{\circ} 27' 55''$.)

This mine is half a mile west of the Clywedog and on the outcrop of the Van lode. It is reached by a rather difficult road, the distance along which to Llanidloes station is about $4\frac{1}{2}$ miles. It appears to have been worked intermittently from the early days of the nineteenth century until about 1876, but its total produce since 1871 is small.

The lode traverses the Upper Van group, but to the north of it the Lower Van grits strike towards the workings, and are crossed by a small north-dipping lode, which runs for a space parallel with, and at a distance of about 30 yards from, the main lode. This has apparently yielded a considerable quantity of galena. The main workings consist of a deep adit (about 820 O.D.), which has been driven from the valley eastward for a distance of about 110 fms. on the lode, and another parallel adit (about 930 O.D.); there is also a shaft from the surface down to the upper adit. The small north lode was worked from a shallow cross-cut at a higher level. Apart from these adits and the cross-cuts from them the workings do not appear to be extensive. Farther east, on the slope of the Clywedog valley, two other adits have been driven westward on the lode and have yielded some galena and blende, together with barytes and witherite; in that neighbourhood also a north lode is present, and some galena has been obtained from a fissure crossing the grit outcrop about 30 yds. south of the main lode.

Output.

Lead-ore was returned in the years 1871, 1873-1876. The greatest output was 51 tons in 1875.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons.	Tons.	%	Oz.	Oz.	Oz.
119	90	75	241 ¹	2·4	3·2

Blende, 32 tons.

BRYNYFEDWEN.

(6-in. Sheet, Mont. 33 N.E., Long. 3° 41' 15", Lat. 52° 33' 35".)

The workings of this mine appear to have been on a group of small lodes which range parallel to the Rhoswydol lode, about 2 miles west of the Twymyn valley and about the same distance north of Dylife. The district is reached from the Twymyn valley by a narrow road and the distance from the mine to the nearest station is 5 to 6 miles.

The principal lode strikes nearly east-and-west and dips at a steep angle to the north. To the south of it, at 180 and 230 yds. distance, two smaller lodes have been explored in adits, but do not appear to have been productive.

¹ The amount of silver contained in the whole of the ore may be estimated at 286 oz.

Output.

Lead-ore was returned in the years 1857 and 1858.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 158	Tons. 109	% 69	Oz. 525 ¹	Oz. 3·4	Oz. 5

CEFNMAENLLWYD.

Exact position unknown. It appears to be one of the small mines, situated on the plateau west of Llanbrynmair, which have not been visited.

Output.

Lead-ore was returned in the years 1855–1858, 1861.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 139	Tons. 103	% 74·1	Oz. 51 ²	Oz. 3·4	Oz. 4·6

CEULAN.

(6-in. Sheet, Mont. 33 N.E., Long. 3° 41' 0", Lat. 52° 33' 50".)

The dressing floors of this mine lie in the Ceulan valley, about 1 mile west of the Twymyn valley and 2½ miles due north of Dylife. Three distinct lodes appear to have been worked, namely, the Rhoswydol lode, the Graig goch or Tyisaf lode and the easterly continuation of the main Brynyfedwen lode. On the former an adit (about 900 O.D.) was driven eastward, and another at a somewhat higher level to the westward. To the south of this lode, midway between it and the Graig goch lode, a vertical shaft was sunk to a considerable depth. On the Graig goch lode an adit (about 800 O.D.) has been driven in a westerly direction, and the Brynyfedwen or south lode, which is about 600 yards to the south, was reached in a shaft. Nothing is known of the extent of these workings. The country-rocks both here and at Brynyfedwen consist of the basal beds of the

¹ The amount of silver contained in the whole of the ore may be estimated at 540 oz.

² The amount of silver contained in the whole of the ore may be estimated at 470 oz.

Frongoch formation, and in the valley adjoining the southern workings, the Gwestyn shales appear from underneath in the crest of an anticline.

Output.

Lead-ore was returned in the years 1857-59, 1861, 1862, 1864, 1870, 1872, 1874, 1875, 1879-88.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 260	Tons. 200	% 77	Oz. 706 ¹	Oz. 4·3	Oz. 5·3

CWMFRON.

(6-in. Sheet, Mont. 48 N.W., Long. 3° 30' 45", Lat. 52° 24' 55".)

This mine lies west of the road from Llanidloes to Tylwch station and about half-a-mile north of the latter place. The lode ranges east-and-west with a southerly dip of 60° to 70°, and has been explored in an adit (about 950 O.D.) driven westward from the base of the hill for about 160 fms. About 40 fms. west of the mouth an engine-shaft has been sunk on the lode to a depth of 48 fms. below the adit, and levels at 12-fm. intervals have been driven mainly in a westerly direction; the longest or 24-fm. level is about 110 fms. in length. Lead-ore was found sporadically to the west of the shaft, but blende predominated. Only such blende was removed as was intimately mixed with galena, and considerable amounts probably remain in the walls of the lode. The lode has been traced along the outcrop over the top of the hill for a distance of about three-quarters of a mile, and near the summit a shallow adit has been driven on it.

Near the railway, three-quarters of a mile northwest of Tylwch, another lode has been tried in shallow adits. It dips steeply to the north, and strikes about N. 40° E. towards the Cwmfron lode at about a quarter of a mile west of the adit-mouth. It is commonly believed that the junction of the two lodes would prove productive, but none of the workings have reached this point. The junction, if it occurs, is not of the most favourable kind, as the intersecting lodes dip in opposite directions. The form of the ground is favourable for testing these lodes about 30 fms. deeper than the present adit by a cross-cut from the valley west of Tylwch station; this would meet the Cwmfron lode in a distance of about 200 fms.

¹ The amount of silver contained in the whole of the ore may be estimated at 1,086 oz.

Output.

Lead-ore was returned in the years 1864, 1871-2.

Lead-Ore.	Lead.	Ratio.
Tons, 33	Tons. 24	$\frac{\circ}{\circ}$ 73

Blende 144 tons.

CWMFRON EAST.

(6-in. Sheet, Mont. 48 N.W., Long. 3° 30' 0", Lat. 52° 24' 55".)

This trial is about half a mile east of Cwmfron; it was also known, from the locality, as Capel Banhadlog. It consists of an adit driven from the side of the road westward on the Cwmfron lode.

Output.

Lead-ore was returned in the years 1868-70.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 72	Tons. 54	$\frac{\circ}{\circ}$ 75	Oz. 169	Oz. 2.3	Oz. 3.1

Blende, 105 tons.

CWMRICKET OR MAESNANT.

(6-in. Sheet, Mont. 40 S.E., Long. 3° 41' 15", Lat. 52° 27' 55".)

This is a small mine on a branch of the Nantyricket lode, which ranges parallel with the Van lode and crosses the Severn about a mile to the north of it (*see* p. 47). A shaft has been sunk to the south of the lode in the Gwestyn shales, and has yielded some galena associated with a little blende. The lode proves to be a downthrow to the south of 40 to 50 yds. It is possibly the westerly continuation of this lode that has been worked at Nantiago, and it may perhaps be traced even farther, into the Plynlimon mine.

Output.

Lead-ore was returned in the years 1874, 1876-78.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 16	Tons. 12	$\frac{\circ}{\circ}$ 75	Oz. 7 ¹	Oz. 7	Oz. 9.3

¹ The amount of silver contained in the whole of the ore may be estimated at 112 oz.

Blende, 1 ton.

CYFARTHFA OR NANTDDU.

(6-in. Sheet, Mont. 33 S.E., Long. 3° 42' 55", Lat. 52° 31' 20".)

Under the name of Cyfarthfa, returns of ore were made from a small mine on the Dyfngwm lode, about a mile west of that mine. The name is, however, applied locally to the slope of the Clywedog valley about half a mile farther east, where some old trials on the same lode occur, about which there is no information nor any evidence of lead-ore having been got. The Nantddu mine consists of a vertical shaft sunk through the Gwestyn shales at a point about 150 yds. west of their base, and about 100 yds. north of the outcrop of the lode which, as elsewhere, dips to the north. The lode is rich in blende intermixed with copper-pyrite, and, as is frequently the case in these rusty shales, associated with ferriferous dolomite and calcite. The explorations do not appear to have been encouraging; blende was apparently not raised, but copper-ore in considerable proportion to the galena was produced. As the lode appears to be highly mineralised and of great width, it may prove more productive at a greater depth where it enters the Van mudstones.

Output.

Lead ore was returned in the years 1872, 1879-81.

Lead-ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons.	Tons.	%	Oz.	Oz.	Oz.
99	85	85	35 ¹	3·8	5·8

¹ The amount of silver contained in the whole of the ore may be estimated at 430 oz.

Copper-ore, 28 tons.

FRONFELEN.

Position not known; probably on the plateau to the west of Llanbrynmair.

Output.

Lead-ore was returned in 1848 and 1874. The greatest output was 15 tons in 1848.

Lead-ore.	Lead.	Ratio.
Tons.	Tons.	%
21	11	52

GEUFRON.

(6-in. Sheet, Mont. 41 S.W., Long. $3^{\circ} 38' 35''$, Lat. $52^{\circ} 27' 25''$.)

This, which appears to be an ancient mine, is situated on the Van lode where it descends into the Severn valley about 4 miles above Llanidloes. The lode is in contact with the Upper Van mudstones and the Gwestyn shales, and dips to the south at about 70° . An adit cross-cut (about 950 O.D.) has been driven eastward upon it; there is also a vertical shaft sunk in the Gwestyn shales, but the extent of the workings is not known. The chief product appears to have been copper-ore, which is associated with iron-pyrite, calcite, chalybite and nests of minute quartz-crystals; there is no evidence that any galena or blende was recovered. There is said to be a deep adit (about 800 O.D.) into the lode near Geufron farm.

Output.

Copper-ore was returned in the years 1851, 1852-55. The total output was 363 tons and the maximum output 212 tons in 1852.

GORN.

(6-in. Sheet, Mont. 48 N.W., Long. $3^{\circ} 29' 55''$, Lat. $52^{\circ} 26' 45''$.)

The main lode of Gorn ranges a few degrees north of east, and has been worked up to the surface on Gorn Hill, about a mile east of Llanidloes station. From the valley east of these workings a deep adit (about 650 O.D.) has been driven westward underneath them, draining the ground to a depth of about 40 fms. Near the mouth of the deep adit another lode enters obliquely from the south, consisting of clay in which occur large lumps of barytes intergrown with witherite. It has not proved possible to keep a level open in this lode, and the mode of occurrence of the minerals is not known. The main lode contains galena admixed with some blende, and the barium-minerals are not present. The main body of ore appears to have been confined to the neighbourhood of the old workings on the hill.

Output.

Lead-ore was returned in the years 1845, 1846, 1848-53, 1855, 1856.

Lead ore.	Lead.	Ratio.
Tons. 331	Tons. 236	% 71

MOEL FADIAN.

This name was given to some trials for copper in the rocks called Creigiau Esgairfochnant, near Glaslyn Lake, 2 miles west of Dylife, in the neighbourhood of which several small adits occur. The country-rocks belong in the main to the Gwestyn formation.

Output.

Copper-ore was returned in 1872, 1873, 1878. The total output was 25 tons, of which 12 tons were returned in 1872.

NANTMELYN OR NANTFELEN.

(6-in. Sheet, Mont. 41 S.W. and 40 S.E., Long. 3° 40' 40",
Lat. 52° 28' 35".)

This is a small mine on a lode dipping to the north and ranging nearly east-and-west through the Van and Gwestyn formations, three-quarters of a mile north of Nantyricket on the Severn. The lode has been explored in an adit (about 1,150 O.D.) and a shaft about 100 yds. to the east, which has been sunk in the Gwestyn shales. The material on the surface indicates that some copper- and iron-pyrite occurred in association with calcite, and it appears from the returns that a fair amount of copper-ore was raised.

Output.

Lead-ore was returned in the years 1848, 1849, 1857, 1863, 1879.

Lead-ore.	Lead.	Ratio.	Copper-ore.
Tons. 59	Tons. 42	% 71	Tons. 43

NANTYRICKET.

(6-in. Sheet, Mont. 41 S.W., Long. 3° 40' 10", Lat. 52° 28' 5".)

This name is given to a group of explorations near the River Severn, 6 miles from Llanidloes. At this point the Lower Van rocks, consisting of beds of grit and coarse conglomerate, are exposed in the core of an anticline, and in the bed of the Severn a wide lode, composed of calcite and copper-pyrite, is exposed among the conglomerate beds. Several adits have been made in the lode and it is stated in a report on the mine that a winze has been sunk below the lowest to a depth of 10 fms. The lode carries copper-pyrite in some abundance associated mainly with calcite. At one point where several calcite- and

copper-lodes appear to unite, the mineralised belt is about 20 ft. wide. The main adit is said to have been driven about 50 fms. west of this junction, and ore has been obtained in the old winze mentioned above, and from an underhand stope in the bottom of the adit.

On the north side of the river, about 200 yds. east of the mouth of the main adit, there is a deep narrow excavation (Lloches y Lladron or Thieves Den) on a lode consisting mainly of vein-quartz, which strikes towards the copper-lode. The dump from this excavation contains a quantity of charcoal, and burnt fragments of grit and slate. On the surface of the heap are numerous rounded stones, which bear evidence of having been used as hammers, the ends of most of them having been bruised or flaked. There is little doubt that this excavation represents ancient workings, similar to those previously described on Copper Hill, Cwmystwyth. It is not known why the excavation was made, for, while copper can be obtained within a short distance to the west, there is no evidence that the lode which occurs here carries any ore.

Output.

Copper-ore was returned in 1872-79, 1899 and 1907. The total output was 209 tons and the maximum output 55 tons in 1875.

PEARCE'S LLANIDLOES.

This is a name given to some trials near the town. The exact position is unknown. Only 2 tons of lead-ore were returned in 1859.

PENYRALLT.

Returns under this name of 10 tons of lead-ore in 1871 appear to refer to some trials on the hill of this name to the west of Llanidloes.

SIGLENLAS.

(6-in. Sheet, Mont. 47 N.W., Long. $3^{\circ} 40' 10''$, Lat. $52^{\circ} 26' 30''$.)

This is a small mine east of the River Bidno, about 4 miles northwest of Llangurig, and about a mile north-east of Nanty mine. The lode appears to range from north-east to south-west across the base of the Frongoch formation, and contains galena in association with masses of quartz, also a considerable amount of copper-pyrite, chalybite and calcite. It has been reached from a shaft and adit, and much work appears to have been done, though according to the returns little ore has been sold. South of the shaft there appears to be another lode which

converges towards the above in a westerly direction, and about 30 yds. east of the shaft there are excavations on a third lode which connects the other two.

Output.

Lead-ore was returned in 1866 and 1868. The maximum output was 20 tons in 1868.

Lead-Ore.	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 31	Tons. 23	% 74	Oz. 56 ¹	Oz. 5	Oz. 7

¹ The amount of silver contained in the whole of the ore may be estimated at 158 oz.

SNOWBROOK OR NANTYREIRA.

(6-in. Sheet, Mont. 40 S.E., Long. 3° 45' 40", Lat. 52° 28' 20".)

This is an ancient working on a north-and-south fissure, which traverses the upper grit beds of the Lower Van formation, about three-quarters of a mile north of Nantiago. The fissure is almost vertical and lies west of the anticlinal axis referred to in connection with that mine. There are other excavations near by, but most of the workings appear to be on this fissure and narrow strings of galena may be seen in the joints of the grits. The débris from the mine contains a large amount of charcoal and burnt stones as at Nantyricket, but no hammer-stones were found. It is stated by Hamer (p. 137) that when the old workings were cleared out in 1859, two or three small picks and wedges were discovered at a depth of 50 ft. below the surface. These were sent to Sir Hugh Williams of Bodelyyddan, who presented them to the Duke of Northumberland; they are now preserved in the Alnwick Castle Museum. Dr. Stanley Smith, who inspected these objects in the Museum, has furnished a brief account of them. There are three exhibits; one (No. 837) is an iron miner's pick with wooden handle, similar to those in use at present; the second (No. 838) is a broken piece of stag's horn with one smooth end, and the third (No. 839) is a remarkably round and smooth stone-ball about 3½ in. in diameter, which is supposed to have been used in crushing the ore. Hamer attributes these workings to the Romans, but there is no independent evidence of Roman occupation in this district. There are extensive traces of ancient shallow excavations and earth-ramparts on the side of the hill about a quarter of a mile south of the mine, but no lode is known to occur there, and it is difficult to account for them.

Output.

Lead-ore was returned in the years 1859, 1860, 1879, 1880, 1882, 1883. The greatest output was 37 tons in 1880.

Lead-ore	Lead.	Ratio.	Silver.	Silver per ton of Ore.	Silver per ton of Lead.
Tons. 161	Tons. 122	% 76	Oz. 996 ¹	Oz. 11	Oz. 14·6

VAN EAST.

(6-in. Sheet, Mont. 41 N.E.)

At this locality extensive explorations were carried out on the Van lode, about three-quarters of a mile east of the Van mine. They have been referred to on p. 43, in connection with the description of the lode; and, although a great length of drivage was carried out and two shafts sunk to test the lode thoroughly, the trials proved abortive. Near the mine the lode is bounded on the north by the Gwestyn shales and on the south by the lower beds of the Frongoch formation, and it is significant that, while it was so rich in the adjoining area on the west, it should have proved all but barren in this mine.

Only 21 tons of lead-ore were returned in 1880.

CHAPTER VIII.

AGE AND ORIGIN OF THE ORES.

The folding, strike-faulting and cleavage which affect the rocks of Cardiganshire and West Montgomeryshire may be attributed to those earth-movements which occurred at the close of the Silurian, and are known to geologists as the Caledonian movements. The general direction of these structures is a few degrees east of north. They are crossed obliquely by the fissures, faults or lodes in which the ore-bodies are found, the general trend of these being east-north-east. There is no clear evidence of the relation to one another of these two sets of structures, but there are indications in various parts of the area that the formation of the east-north-east faults and lodes may be attributed to the same set of movements that caused the folds and strike-faults. Thus, on the Severn near Nantyricket, the rapid diminution in the displacement of the Nantyricket lode, with increasing distance from the crest of the anticline which it traverses, suggests that the formation of the fold was assisted by movement along the lode, and that the same under-

¹ The amount of silver contained in the whole of the ore may be estimated at 1,776 oz.

lying stresses were responsible for both structures. Again, it may be observed that the Hafan lode crosses an anticlinal axis at the point where a change of pitch takes place. It is difficult to account for such a relation except on the view that at least some of the transverse faults are broadly speaking, contemporaneous with the folding. In general, however, the faults belong probably to a late stage of the movements. An early age for the lode-fissures is suggested independently by other considerations. The Llyfnant fault in the north, and probably the Ystwyth fault in the south, of the district, traverse and displace fold-axes and strike-faults; the Ystwyth fault interrupts also the main lodes of Cwmystwyth, and throws them down through a vertical distance of over half a mile. These lodes were thus in existence prior to the formation of such faults, and at Cwmystwyth there are good grounds for believing that they were fully mineralised before the faulting occurred (*see* p. 34). No definite age can be assigned to these faults; they appear to exert a marked influence upon the topographic features of the district, and for this reason it has been suggested that they may be of as recent a date as the middle of the Tertiary period.

On the other hand, the magnitude of their effects accords better with a higher antiquity. So far as is known, there is no displacement in the southern part of the British Isles of later date than the post-Carboniferous, pre-Triassic movements, which is comparable in effect with the two great faults mentioned, and they may be assigned with some probability to that period. The mineralisation of the lodes which preceded the formation of the faults may thus be assigned to some part of the interval between the close of the Silurian and the close of the Carboniferous.

Finlayson¹ has brought forward reasons for the view that the lead-zinc lodes of Central Wales—and, in fact, of all the Palæozoic rocks of Wales, Northern England, Southern Scotland and most of Ireland—are of somewhat later date, and probably related to the post-Carboniferous or “Hercynian” movements. In this view, he was influenced by the occurrence of numerous lodes in connection with the intrusive rocks of Devon and Cornwall which are of that age, and also by the existence of lead- and zinc-ores in lodes which traverse the Carboniferous rocks of North Wales and the North of England.

Direct evidence of the relation of the lodes in the slaty rocks to those in the Carboniferous strata is wanting in Central Wales, since no formations younger than the Silurian occur in the area. Further, no connection can be established between these lodes and igneous rocks; none such are found at the surface, nor is there any reason to suppose that they exist at a moderate depth beneath the region.

It is now generally accepted that there is a close genetic connection between the lead-silver-zinc lodes in slaty rocks and

¹ *Quart. Journ. Geol. Soc.*, vol. lxvi., p. 281, 1910.

the phenomena of igneous intrusion.¹ This connection implies that the ultimate source of the ores is deep-seated, though the nature of the solutions which have introduced the ores and their associated minerals into the fissures is unknown, as are also the processes by which they have been deposited. In view of the probable past geological history of Central Wales, it is difficult to conceive of the lode-filling as having been derived from any other source. The igneous activity which followed the post-Carboniferous movements was, however, specially characteristic of the south-west of Britain, whereas in the northern area, from Wales to Scotland, it is related in the main to the earlier Caledonian movements.

Finlayson regards the scattered occurrences of blende, galena and copper-ores in the Mesozoic rocks of several English counties, as representing the last phase of Hercynian ore-deposition, extended well into the Mesozoic era. By a similar argument, the ores in the Carboniferous rocks might be attributed to the final phase of ore-deposition which commenced in connection with the earlier Caledonian movement.

In view of the antiquity of the lodes, it is evident that since their formation, denudation must have removed a great thickness of cover from the district as a whole, and it is conceivable that, in this process, the material which was scattered through a large extent of lode has been concentrated to form the ore-bodies which lie near the present surface. It must be admitted, however, that as regards the lodes of this district, there is no satisfactory proof of a secondary enrichment of this type. Moreover, as is indicated below, it is doubtful if the lode-fractures extended any great distance upward into the overlying cover of rocks. The structure of the lodes, the character of the lode-filling and the relation to one another of the lode-components (*see* p. 184), suggest that the filling is primary, and that all the components of the lode have been formed in one general process of ore-deposition.

The main constituents of the lodes are quartz and sulphides of lead, zinc, copper and iron. Calcite and dolomite are comparatively rare, and where they occur, are usually in association with copper-ores; this is in itself suggestive of a primary relation. These constituents often occur in a regular succession, either coating the walls of the lode or surrounding pieces of included country-rock. The succession is not always the same, and it may be inferred that the general conditions were much the same for the formation of quartz as for galena, blende, or marcasite. The quartz associated with ores is usually distinct from vein-quartz which is found filling fractures in rocks of various ages, or even in mineral lodes, and the conditions necessary for the formation of this lode-quartz were apparently different from those required to form vein-quartz. They prevailed only while

¹ Beyschlag, Vogt and Krusch, *Deposits of Useful Minerals*, trans. by Trusecott, p. 650.

ore-deposition was taking place in the lode and have not recurred. Vein-quartz has formed at various times.

Again, if the ore-bodies are to any sensible extent the result of secondary enrichment, some evidence of this ought to appear in the presence of secondary minerals and in the silver-content of the ore. Secondary minerals are all but absent in this mining field, except locally, and quite near the surface, while, so far as any evidence can be obtained, there is no reason to believe that the silver-content of the ore-bodies near the surface is greater than at a depth (*see pp. 68, 71*), as ought to be the case if secondary enrichment had played a part. On the other hand, at Esgairmwyn, the silver-content increases somewhat rapidly in the deeper levels of the mine (*p. 127*).

The productive portions of the lodes, as indicated by the distribution of the mines, appears to be related in some manner to the rocks of the district. Each lode in turn ceases to be productive west of a line drawn from Aberdovey to Gwaithgoch in the Ystwyth valley; while farther south Llwynmalus mine only lies to the west of that line. The significance of this abrupt limitation is not clear, though it probably indicates that the lodes cease to carry ore in payable quantity at what is approximately a stratigraphical horizon. It may be estimated that at Talybont, Penycefn, Bronfloyd, and Red Rock, near Frongoch, which lie near the above line, the country-rocks are in each case about 3,000 ft. above the base of the Frongoch formation. The great fault in the Ystwyth valley, which carries the base of that formation nearer the surface, probably explains the occurrence of mines west of the above line, south of that valley. Again, so far as is known, there are few cases where ore-bodies, which are rich in the Frongoch formation, persist downward into the underlying Gwestyn rocks. The main ore-bodies of this part of the district are therefore confined between two stratigraphical horizons, and in discussing future prospects this must be borne in mind. In view of the fact that the main ore-bodies lie just above the highly pyritous shales distinguished as the Gwestyn formation, it may be suggested that the deposition of ore has been facilitated by the presence of the finely-disseminated iron-pyrite which imparts to that formation its distinguishing characters.

The Cwmystwyth district is an exception to the rule just discussed. The ore-bodies there lie among the grits of the Cwmystwyth formation, and are probably about 5,000 ft. above the base of the Frongoch rocks. At Logaulas the same lode-belt is, however, productive at the lower horizon. It is possible that the deposition of the ore in the Cwmystwyth district is related to a group of soft dark-blue shales about 500 ft. thick, which underlies the grits and is abundantly pyritous. Given the fissures and the mineralizing solutions, then so far as regards the surrounding rocks, the conditions for ore-deposition near the base of the Cwmystwyth grits would not differ greatly from

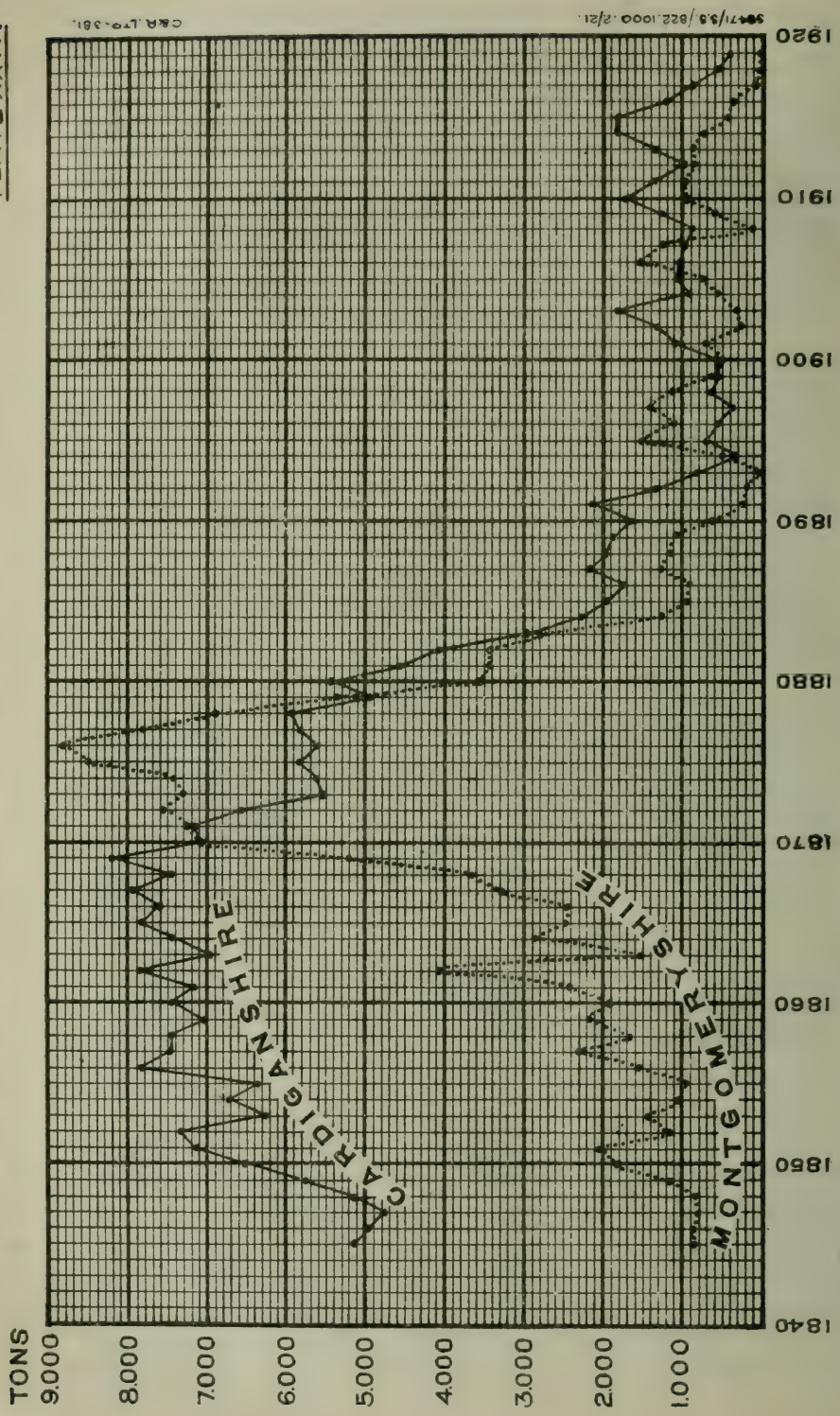


CHART SHEWING ANNUAL OUTPUT OF LEAD ORE
FOR CARDIGAN & MONTGOMERY.

those near the base of the Frongoch formation. At Cwmystwyth, too, the lodes become barren where they pass laterally or vertically into the underlying shale-group.

The conditions underneath the eastern areas where the Van rocks occur at the surface are not known. The Van and Nantiago mines, which have yielded the bulk of the ore in those areas, lie, on the whole, in the upper part of the Van formation, the grits of the Lower Van group being entered only in the bottom of the mines. In the Plynlimon district north of Nantymoch, there is a great thickness of highly pyritous shales below the Lower Van grits, and it is probable that similar rocks underlie those grits in the Van and Nantiago district but at a smaller depth. It is, therefore, instructive to note that the ore-bodies of Cardiganshire and Montgomeryshire tend to occur at certain definite stratigraphical levels, each of which is underlain by a group of pyritous shales. It is difficult to believe that the connection is wholly accidental.

INFLUENCE OF THE COUNTRY-ROCKS UPON THE LODES.

Many of the lodes can be traced across more than one formation, but the distribution of the ore-bodies appears to be related in some manner to the structure and the nature of the country-rocks; this is seen by referring to the table on p. 197. Out of a total of 133 mines, 95 lie in the Frongoch formation; 6 lie partly in the Gwestyn and partly in the Frongoch formations; 16 in the Gwestyn, and 16 in the Van rocks. Nearly three-quarters of the mines occur, therefore, where the lodes traverse the Frongoch rocks and, further, nearly half the total output of ores is derived from lodes which lie in this formation.

The influence of the Gwestyn shales is rather strikingly illustrated in the same table, for the average output of lead-ore from each mine in these rocks is only from one-fifth to one-sixteenth of the average output from mines in other formations, and the proportion is nearly the same if the total ores are taken into account. If only the mines which have returned over 1,000 tons are considered, the average output per mine lies between one-quarter and one-eighth of that from mines in other formations. It is significant, too, that where the lodes traverse those rocks, a fairly high proportion of copper-ore is a characteristic feature. The ratios of lead-ore, blende, and copper-ore are indicated in the table, but it will be sufficient to consider the proportion of copper-ore to the ores of lead and zinc together. This proportion, which is about 1 in 220 in the Van formation and about 1 in 660 in the Frongoch, rises to 1 in 3 in the Gwestyn shales. The influence of the same rocks is indicated also in those mines which lie partly in the Frongoch and partly in the Gwestyn formation; the proportion of copper-ore to lead- and zinc-ore in six such mines is about 1 in 22.

The distribution of silver in the ore does not appear to obey any clearly-defined law. The richest mines are those between Goginan and Daren; to the south, as far as Logaulas, the ores are poor in silver, but the adjoining Glogfach, Glogfawr and Esgairmwyn mines have a fairly high content. In the eastern districts, both Van and Dylife, and some of the smaller lodes farther north, *e.g.*, Brynyfedwen, carry a notable amount of silver. A tradition that the older mines in Cardiganshire were very rich in that metal has received no confirmation, and there is little indication in the records that the silver-content was appreciably greater at higher levels than at a depth. Indeed, at Esgairmwyn, the workings of the last 30 years have proved a remarkable increase of silver in the lower parts of the mine. It is possible that the tradition arose from the fact that, owing to the high price of silver, the majority of the older mines were worked mainly for the purpose of extracting that metal, the lead being relatively unimportant.

There seems also to be some relation between the distribution of the ore-bodies and the structure of the rocks, both on a large scale and to some extent in detail. The majority of the mines lie on the flanks of the broad anticlinal tract of Plynlimon. In the case of the two lodes which can be traced with some certainty from Cardiganshire to Montgomeryshire, it is a curious fact that they are mainly productive near their eastern and western limits, and in the intervening tract remarkably barren. The present survey has proved, too, that the ore-bodies within the limits of a mine are related to certain anticlinal axes. The three mines, East Daren, Cwmerfin and Goginan, lie on the east flank of the same anticline, and in each case the lode becomes barren as it approaches the crest. Similar conditions probably occur elsewhere, but as the majority of the mines have ceased working, accurate information as to the relation between the ore-bodies and the structure of the adjoining rocks is difficult to obtain. In many cases, too, the form of the ore-body corresponds approximately with the structure of the bedded country-rocks adjoining the lode. This is seen more particularly at Logaulas, East Daren, Cwmerfin, Llanerchyrour and Nantiago, and in the two last-named mines the correspondence seems too close to be accidental. Within the ore-bodies there is usually evidence of "shoots" of ore, and in the majority of cases these shoots dip to the west; this may be related to the direction of movement in the walls of the fissure, which is often indicated by grooves or striations on the footwall. These are generally inclined to the west at an angle of about 60° from the horizontal.

ASSOCIATION OF MINERALS.

The most usual association of minerals is galena, blende, and clear or bluish quartz, in a brecciated lode composed of slaty fragments. Occasionally, as at Loveden and Nantiago, both in the Van formation, calcite replaces quartz as the chief "spar."

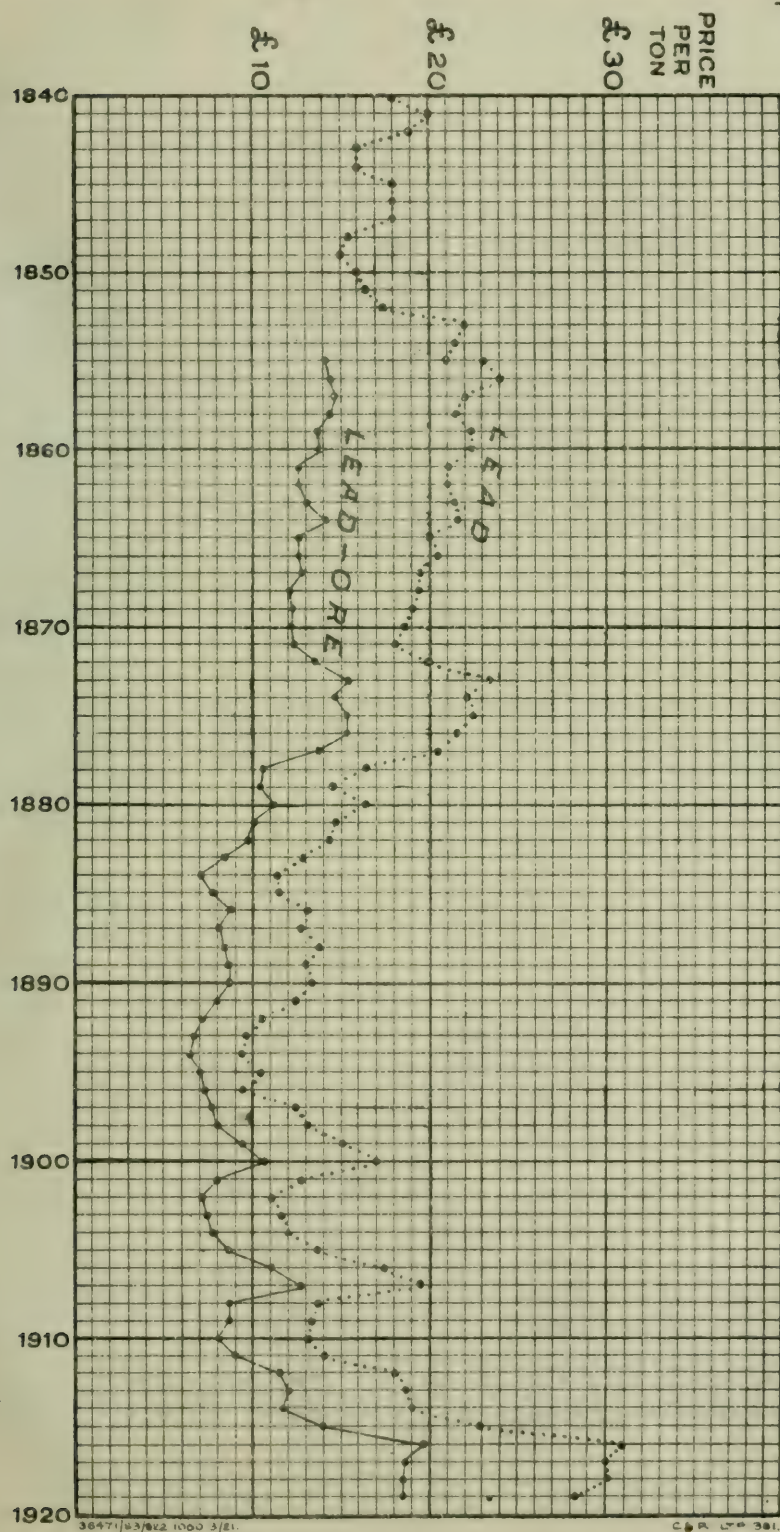


CHART SHEWING PRICE PER TON OF
LEAD & LEAD-ORE FROM 1840 TO 1919:—

Copper-pyrite is most commonly found where lodes traverse the Gwestyn shales or the rocks immediately above or below, as at Esgairfraith, Dyfngwm, Dylife, Nantddu, South Daren, Dyffryn Castell and Geufron. Exceptionally it is found in some abundance at lower or higher levels, for example at Nantyricket and Copper Hill, Cwmystwyth. This ore occurs in two associations, namely, with galena, blende and quartz, or more commonly with ferriferous calcite and dolomite or chalybite. These carbonates seem, in fact, to be the normal associates of copper-pyrite in this district. Iron-pyrite and marcasite in any abundance are of local occurrence; they are found in the Castell lode in the Ystumtuen district and in parts of the Brynrafr mine. It is difficult to deduce a general rule relating to the order of deposition of the minerals in the lodes. It probably depends, among other factors, on the relative concentration of the minerals in the ore-bearing solutions, and the structure or grain of the ore may, perhaps, be attributed to the same condition. The sequence of minerals is observable most commonly around fragments of slate or in narrow fissures. In the majority of cases, the fragment is coated with a thin film of crystallised quartz, and the narrowest cracks are usually completely closed by the same mineral. The quartz is commonly followed by blende; and, if galena is present, it is deposited on the blende and within such cavities or fissures as have not been already filled by the previous minerals. Where spaces still remain unoccupied, a further deposition of crystallised quartz has usually occurred, and occasionally growths of copper-ore, or iron-pyrite, may be observed on crystals of galena. This appears to be the general order, but it is subject to many exceptions. In some cases well-developed, scattered crystals, usually of galena, but occasionally of blende or copper-pyrite, have grown upon the second quartz layer. They are, thus, later than the main ore-deposition and may probably be attributed to secondary re-arrangement at a later period. The influence of relative concentration of the minerals in the ore-bearing solutions, and possibly also of supersaturation, may perhaps be traced in the structure of the ores. Some galena occurs in exceedingly small aggregates showing no crystalline outlines ("steel ore"); a similar structure is usually characteristic of masses of blende. In other cases the ores tend to form well-developed crystals, sometimes of large size, which are usually scattered as "spots" through the lode. Analogy with other crystalline growths suggests that the aggregates were deposited from highly-concentrated or super-saturated solutions, and the well-developed crystals from less concentrated solutions. In some mines (Cwmystwyth and Rhoswydol) blende tends to form spherical masses from 1 to 4 in. in diameter, composed of needle-shaped or blade-like crystals radiating from a centre, and not uncommonly surrounding a fragment of slate. Such growths are generally characteristic of crystallisation from strongly super-saturated solutions.

Where copper-pyrite occurs in association with carbonates the deposition of the ore preceded that of the spar; in some cases the latter has been coated in turn with crystallised quartz which has moulded itself on the spar-crystals. The general succession seems to indicate that the mineral-filling belongs, in a broad sense, to one phase of ore-deposition, and that no considerable interval separated the opening of the fissures or cavities and the deposition of the ore. Finlayson¹ arrived at the same conclusion from the study of the ore-deposits of the British Isles as a whole. This is strikingly indicated by the thinness of the film of quartz which divides the rock-fragments from the ore. If the interval had been long it is difficult of belief that the spaces would not have been largely filled by the deposition of quartz or calcite. In the majority of the lodes there is no evidence of renewed movement and re-opening of the fissures, and in some cases, where they contain delicate growths of ore or spar, it is clear that no movement has occurred since those growths, which in that event must have been destroyed. In a few instances, however, there is reason to believe that some movement has taken place; at Brynrafr masses of ore may be found consisting of a breccia of blende and rock-fragments lying in various directions and cemented by quartz of lode-type. This is the only example where no film of quartz can be detected between the blende and the enclosed rock-fragments, and seems to point to very early ore-deposition. Again at Cwmystwyth, the main lodes, Comet and Kingside, have been displaced by Mitchell's lode which is itself mineralised. In that district, therefore, renewed movement had taken place before the phase of mineral-deposition had passed away.

THE PAST HISTORY OF THE INDUSTRY.

The most flourishing period in the history of the industry appears to have been between 1850 and 1870, and apart from certain crises this period was on the whole one of relatively high prices. In 1870 the output was already beginning to decline, and a few years later this decline was hastened under the influence of low prices (*see* Pl. XXV.) which were due in the main to the introduction of foreign ores, stimulated by the high prices in the early 70's and the rapid development of steam-shipping. From the early 90's, when the prices reached their lowest level, to the present time the industry has been in a moribund condition. It must be observed, however, that, with the exception of the Van mine, the output had begun to decline (*see* Pl. XXIV.) before the fall in prices set in, and it is clear that many of the mines were already approaching exhaustion of their known ore-reserves. It is unfortunate, therefore, that at the very time when exploration-work should have been most active, the general fall in prices made it necessary to reduce costs of working to a

¹ *Op. cit. sup.*, p. 287.

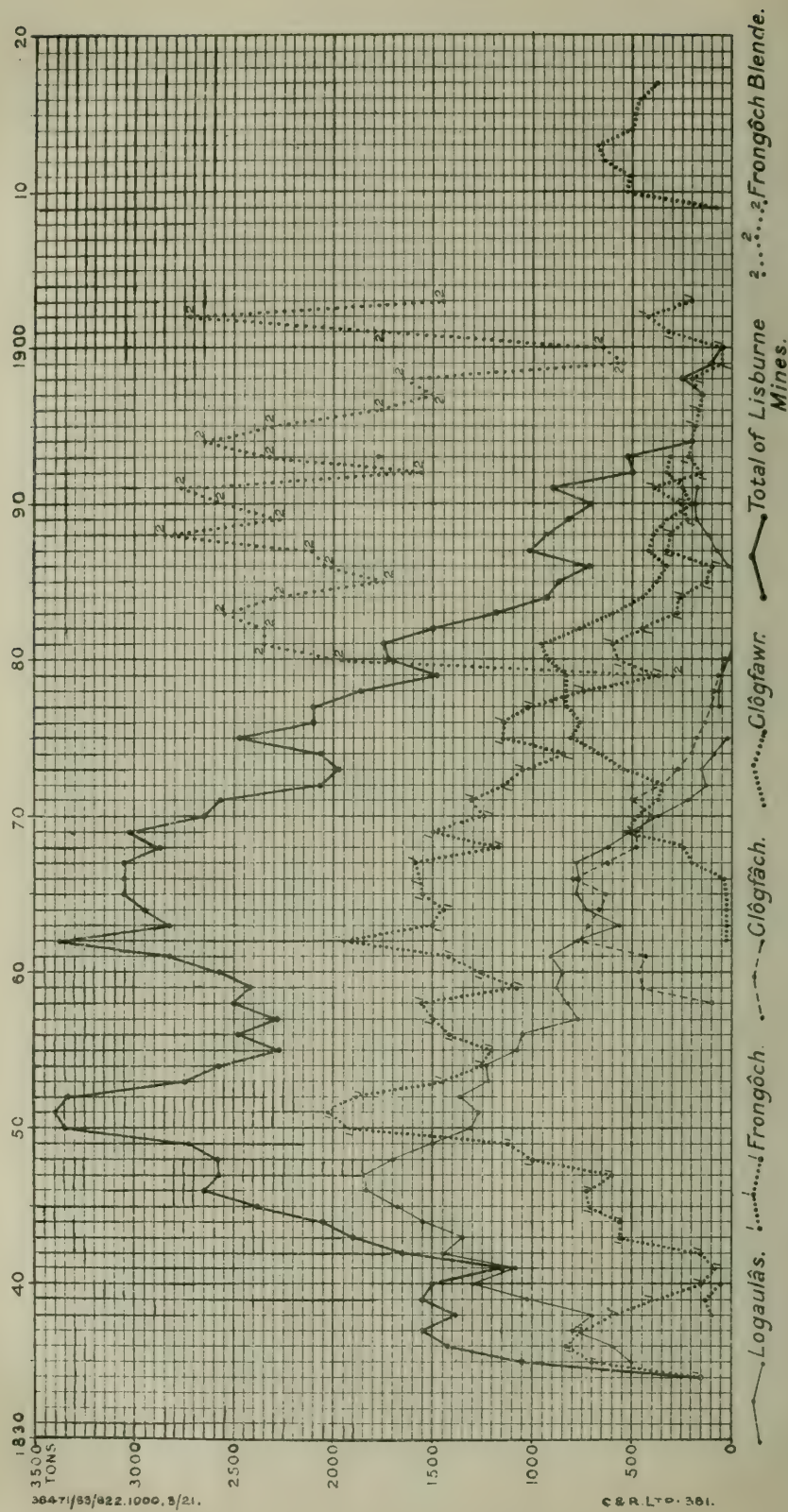


CHART SHEWING OUTPUT OF THE LISBURN GROUP OF MINES.

minimum, or to close down the mines. It is apparent from the records furnished by the plans that comparatively little investigation of the lodes at a depth has been made beyond the limits of the payable ore-bodies which had been worked down from the surface. The helplessness of the mines during this period of depression was largely the result of a financial practice which had been prevalent in the district. The bulk of the profits were distributed each year as dividends, and little, if any, reserves were maintained. A mine was regarded more as an adventure than as a business, and many mining companies of that period were, in fact, styled by themselves as "companies of mine adventurers." Other causes contributed to increase the difficulty of working the mines economically; some of the lodes traversed land belonging to different owners, and it was often difficult to obtain satisfactory terms or, indeed, any terms, to enable a large extent of lode or several mines to be worked under one management. It would have been greatly to the advantage of the industry if a number of mines had been grouped together, so that temporary deficiencies in one mine were covered by new discoveries in others belonging to the same group. This system would have reduced the overhead charges of the mines, as well as the costs of drainage or pumping, and of dressing the ore. The Lisburne mines worked by Messrs. Taylor & Sons for over 60 years afford a conspicuous example of the success to be obtained from the adoption of this system (see Pl. XXVI.). The methods of dressing the ores have not in general been economical, entailing a considerable loss of galena, and an even greater loss of blende. In many cases, too, particularly during the flourishing period, the mines were a prey to speculators, and considerable sums of money were spent in providing elaborate machinery before the capacity of the mine to supply it with ore had been proved.

FUTURE PROSPECTS OF THE AREA.

With a few exceptions there are no considerable reserves of ore in the mines. Most of the ore that has been worked hitherto has been derived from ore-bodies that either out-cropped at the surface, or were discovered at a small depth beneath the surface. The majority of these have probably been exhausted. The future depends, therefore, upon such success as may be obtainable in further prospecting. This investigation, if carried out, should take into account the geological horizons at which the ore-bodies have been mainly found, the nature of the surrounding rocks and the geological structure; in particular, the influence of the Gwestyn shales should be investigated. It seems clear that several productive mines became impoverished on entering these shales in depth, but there is no evidence in those cases that the shales have been penetrated to any distance. Inasmuch as the upper beds are softer and more pyritous than any other part of the shale-group, it is possible that the lodes

may become once more productive on reaching a harder part of the formation, or, failing that, in the underlying Van formation which includes the most productive mine in the district. Past experience suggests that better results will be obtained by investigating the larger lodes, and the fractures related to them, than by searching for new lodes, for it is not probable that any important lodes remain undetected. Possibly, in some areas, small lodes may be discovered carrying a certain amount of ore, but the life of mines working such lodes has been generally short. Out of 125 mines which have returned ore since 1845, two-thirds of them produced for less than 10 years. Including these, the average life of all the mines is about 13 years, but if these tentative explorations are omitted, the average life of the remainder is increased to about 30 years.

During the earlier years, when the mines passed through a prosperous phase, the labour costs were low, and mining did not form the sole occupation of many of the workers. On this account the district was placed at an advantage compared with other areas.

In future operations account must be taken of the considerable increase in the cost of labour, which tends more nearly to approach the standard of other industrial areas. An argument is being applied that, in deciding on the wages appropriate to the industry, no account should be taken of other occupations (more particularly farming) in which the miners may be engaged.

Labour-costs may be considerably reduced by the adoption of improved mechanical devices for handling the ore, and of better methods of recovering the ore in dressing. In many parts of the district the costs of pumping or drainage would be lowered by co-operation between the lessees of adjoining properties.

It may be suggested too, that the exceptional facilities which the district affords for developing water-power, should be turned to the advantage of the industry.

APPENDICES.

BIBLIOGRAPHY.

- | | | | | |
|-------|-----------------|---|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1670. | Sir John Pettus | - | - | Fodinae Regales. |
| 1698. | W. Waller | - | - | An Essay on the Value of the Mines, late of Sir Carberry Price, London. |
| 1700? | W. Waller | - | - | Present State of the Mines. (Esgairhir, Bwlch Cyneiniog, Cwmsymlog, Goginan, Brynpica, Bwlch, Pencraigddu, Ystumtuen and Cwmystwyth.) |
| 1810. | S. R. Meyrick | - | - | History of Cardiganshire. Introduction (Mineralogy), pp. cciii-cclxii. |
| 1847. | A. Sedgwick | - | - | On the Classification of the Fossiliferous Slates of North Wales, Cumberland, Westmorland and Lancashire.— <i>Quart. Jour. Geol. Soc.</i> , vol. iii, p. 133. |
| 1848. | R. Hunt | - | - | Notices of the History of the Lead Mines of Cardiganshire.— <i>Mem. Geol. Surv.</i> , vol. ii, pt. 2, pp. 635-654. Contains numerous references to Pamphlets bearing upon the early History of the Mines. |

1848. W. W. Smyth - - - On the Mining District of Cardiganshire and Montgomeryshire.—*Ib.*, pp. 655–684.
1848. R. Hunt - - - Produce of Lead-Ore and Lead in the United Kingdom for the years 1845 and 1846.—*Ib.*, pp. 703–717.
1866. A. C. Ramsay - - - The Geology of North Wales.—*Mem. Geol. Surv.*, vol. iii, 1st ed. 1866, 2nd ed. 1881.
1873. } Ed. Hamer - - - Parochial Account of Llanidloes. Pt. 1,
1876. } 1873, Pt. 2, 1876.
1874. Absalom Francis - - The History of the Cardiganshire Mines. Aberystwyth.
1878. W. Keeping - - - Notes on the Geology of the Neighbourhood of Aberystwyth.—*Geol. Mag.*, 1878, p. 532.
1879. C. le Neve Foster - - The Van Mine.—*Trans. Roy. Geol. Soc. Cornwall*, vol. X., p. 33–46, 1887.
- About Liscombe & Co. - - The Mines of Cardiganshire, Montgomeryshire and Shropshire.—Liverpool. Privately Printed?
- 1880.
1881. W. Keeping - - - The Geology of Central Wales.—*Quart. Jour. Geol. Soc.*, vol. xlii, p. 141.
1900. H. Lapworth - - - The Silurian Sequence of Rhayader.—*Quart. Jour. Geol. Soc.*, vol. lvi, p. 67.
1905. H. Lapworth - - - The Geology of Central Wales.—*Proc. Geol. Assoc.*, vol. xix, p. 160.
1906. E. M. R. Wood - - The Tarannon Series of Tarannon.—*Quart. Jour. Geol. Soc.*, vol. lxii, p. 644.
(Mrs. G. A. Shakespear.)
1909. O. T. Jones - - - The Hartfell-Valentian Succession in the District around Plynlimon and Pont Erwyd (North Cardiganshire).—*Quart. Jour. Geol. Soc.*, vol. lxxv, p. 463.
1910. W. G. Fearnside - - Geology in the Field.—*Jubilee Volume Geol. Assoc.*, p. 786.
1910. A. M. Finlayson - - The Metallogeny of the British Isles.—*Quart. Jour. Geol. Soc.*, vol. lxvi, p. 281, and *Problems of Ore-Deposition of Great Britain*, p. 299.
1911. Various Authors - - Aberystwyth and District.—*Nat. Un. of Teachers' Handbook, Aberystwyth*.
1912. O. T. Jones - - - The Geological Structure of Central Wales and the Adjoining Regions.—*Quart. Jour. Geol. Soc.*, vol. lxxviii, p. 328.
1915. O. T. Jones and W. J. Pugh. The Geology of the District around Machynlleth and the Llyfnant Valley.—*Quart. Jour. Geol. Soc.*, vol. lxxi, p. 343.

The Numbers correspond to those on the Map.

Nos. 19, 21, 29, 30, 31, 49, 55, 60, 62, 64, 78, 89, 90, 92, are not inserted on Map.

ALPHABETICAL LIST OF MINES.

CARDIGANSHIRE.

No.	Name of Mine.	No. of Years worked.	Year of Greatest Output and Amount in Tons.		Total Output in Tons.			Average Output of Lead-ore in Tons.
					Lead-ore.	Blende.	Copper-ore.	
1	Abbey Consols or Florida.	27	1872,	287	1,236	1,765	—	46
2	Aberffirwd -	6	1855,	66	236	—	5	39
3	Aberystwyth -	11	1853,	50	277	285	—	25
	Bwlchgwyn -	3	1887,	10	19	—	—	6
	Nanteos -	10	1851,	459	2,261	28	—	226
	Nanteos and Penrhiw.	5	1860,	306	936	—	—	187
	Penrhiw -	11	1916,	140	534	249	—	49

CARDIGANSHIRE—continued.

No.	Name of Mine.	No. of Years worked.	Year of Greatest Output and Amount in Tons.	Total Output in Tons.			Average Output of Lead-ore in Tons.
				Lead-ore.	Blende.	Copper-ore.	
4	Alltycrib -	30	1872, 174	1,335	10	3	44
	Alltycrib N., &c.	2	1872, 140	195	—	—	75
	Tanyrallt -	16	1881, 110	749	—	—	47
	Alma (<i>see</i> Llechweddhen).						
5	Blaenceulan -	8	1871, 250	438	7	18	54
6	Blaencennant -	6	1870, 27	72	62	—	12
	Blaendyffryn (<i>see</i> Silver Stream).						
7	Bodcoll or Gertrude.	7	1873, 154	348	—	—	50
8	Bog or Craignantbach.	13	1873, 250	1,542	702	—	119
9	Bronfloyd -	36	1871, 550	6,423	—	23	178
10	Brynarian and Pensarn.	7	1851, 95	294	53	—	42
11	Bryndyfi or Neuaddlwyd.	1	1882, 24	24	—	—	—
12	Brynglas -	2	1860, 32	41	—	—	20
13	Brynyrafr -	31	1889, 359	4,952	8,116	—	160
	Brynystwyth (<i>see</i> Grogwynion).						
14	Bwadrain and Bwadrain S.	10	1869, 364	1,744	8	—	174
15	Bwlch -	35	1869, 558	7,750	7	—	221
16	Bwlchglas -	10	1915, 506	1,240	99	—	124
	Bwlchgwyn (<i>see</i> Aberystwyth).						
17	Caenant or Ceunant.	3	1845, 10	22	—	—	7
18	Caegynon -	10	1858, 56	371	717	—	37
19	Camdwrbach, or Cambrian S.	2	1904, 21	—	26	—	—
20	Camdwrnawr -	1	1856, 5	5	—	22	—
21	Caron -	5	{ 1878 } 1879	30	89	—	18
22	Castell -	3	1874, 109	139	5,365	25	46
23	Cefngwyn -	9	1881, 29	150	—	—	17
	Ceunant (<i>see</i> Caenant).						
24	Clara -	11	{ 1871 } 1872	40	194	30	18
	Court Grange (<i>see</i> Penycefn).						
	Craignantbach (<i>see</i> Bog).						
25	Cwmbrwyno -	38	1854, 630	6,095	796	—	160
26	Cwmdaren or Copper Level.	5	1855, 50	121	—	94	24
27	Cwmerfin -	29	1865, 798	9,919	38	60	342
	Cwmerfin W. (<i>see</i> Melindwr).						
28	Cwmnawr -	5	1914, 358	836	131	—	167
29	Cwmpryfi -	3	1880, 30	51	—	—	17

CARDIGANSHIRE—continued.

No.	Name of Mine.	No. of Years worked.	Year of Greatest Output and Amount in Tons.	Total Output in Tons.			Average Output of Lead-ore in Tons.
				Lead-ore.	Blende.	Copper-ore.	
	Cwmsebon (<i>see</i> Daren S.).						
30	Cwmsymlog W.	2	1867, 8	13	—	—	6
31	Cwmsymlog N.	1	1868, 5	5	—	—	—
32	Cwmystwyth -	61	1858, 1,483	32,912	18,913	—	540
33	Cwmystwyth S.	1	1878, 40	40	—	—	—
34	Cwmystwyth W.	3	1877, 10	20	—	—	7
35	Daren -	27	1873, 167	1,657	—	52	61
36	Daren E.	48	1857, 1,034	24,460	—	95	510
37	Daren S. or Cwmsebon.	44	1880, 570	9,248	196	1,048	210
38	Dolclettwr or Llainhir.	4	{ 1855 } 1856	5	16	147	80
39	Dolwen or De Broke.	10	1877, 221	831	—	—	83
40	Eaglebrook or Nantycagal.	10	1856, 152	598	—	71	60
41	Elgar -	2	{ 1889 } 1890	2	4	4	—
	Ella (<i>see</i> Hendrefelen).						
42	Erglodd -	2	1882, 10	16	12	—	8
	Erwtomau (<i>see</i> Rheidol United).						
43	Esgairlle and Great West Van.	14	1872, 268	1,256	7	—	90
		12	1874, 265	813	—	—	87
44	Esgairhir and Esgairfraith.	34	1856, 516	2,819	—	2,690	83
45	Esgairmwyn - Florida (<i>see</i> Abbey Consols).	44	1910, 810	10,430	108	140	237
	Foxpath (<i>see</i> Rheidol United).						
46	Frongoch -	59	1851, 2,036	50,669	50,856	11	858
47	Frongoch W. or Wenys.	25	1883, 150	1,274	1,975	—	51
48	Gelli' reirin or Gelli.	9	1859, 209	706	—	—	79
	Gertrude (<i>see</i> Bodcoll).						
49	Glanrheidol -	1	1866, 73	73	50	—	—
50	Glogfach -	31	1866, 800	9,610	—	—	310
51	Glogfawr -	40	1881, 960	18,520	—	18	463
52	Goginan -	42	1845, 1,785	17,257	60	—	411
53	Goginan W. -	2	1879, 6	7	—	—	3
	Gothic (<i>see</i> Rheidol United).						
	Graiggoch (<i>see</i> Red Rock).						
	Great West Van (<i>see</i> Esgairlle).						
54	Grogwynion or Brynyswyth.	30	1877, 1,200	8,874	—	—	296
55	Grogwynion N. or Pantauhirion.	2	1882, 60	62	—	—	31
56	Gwaithgoch -	4	1860, 35	104	—	—	26

No.	Name of Mine.	No. of Years worked.	Year of Greatest Output and Amount in Tons.		Total Output in Tons.			Average Output of Lead-ore in Tons.
					Lead-ore.	Blende.	Copper-ore.	
57	Hafan and Hen-fwlch.	6	1864,	261	623	4	25	104
58	Hendrefelen or Ella.	1	1870,	20	20	—	—	—
59	Imperial (see Pantmawr). Leri, Leri Valley or Penpont-bren uchaf	6	1858,	79	212	109	5	35
60	Lisburne New -	2	1864,	7	13	—	—	6
61	Lisburne S. -	3	1860,	64	131	599	—	43
62	Llanbadarn -	1	1848,	33	33	—	—	—
63	Llancynfelyn -	2	1855,	21	25	—	—	12
64	Llanerch -	1	1856,	4	4	—	—	—
65	Llawrcwmbach	19	1859,	100	477	—	—	25
66	Llechweddhen or Alma.	2	1853,	161	184	—	—	92
67	Llechweddhelyg	1	1853,	3	3	—	—	—
68	Llettyhen or Vaughan.	13	1878,	177	581	282	—	45
69	Llwynmalus -	14	1856,	101	786	20	—	56
70	Llywernog including Powell and Ponterwyd.	28	1868,	360	3,813	560	—	136
71	Logaulas -	41	1847,	1,850	28,664	—	—	699
72	Loveden -	12	1903,	244	997	5	—	83
73	Melindwr, Melindwr Valley, Ty'nypwll or Cwmerfin W.	5	1875,	100	186	—	—	37
74	Moelglomen -	1	1865,	1	1	—	—	—
75	Mynach Vale or Tygwyn.	6	1882,	96	194	—	—	32
76	Mynyddgorddu Nantycagal (see Eaglebrook)	11	1880,	240	901	183	—	82
77	Nantyreiau - Nantyrarian (see Silver Stream). Neuaddlwyd (see Bryndyfi).	23	1882,	124	905	6,057	—	39
78	New Bog, Tredol. Pantauhirion (see Grogwynion N.).	1	1887,	6	6	—	—	—
79	Pantmawr, Imperial or Silver Mountain.	4 3	1845,	48	121	—	—	30
	Penclayen (see Rheidol United).		1846,	120	143	—	—	48
80	Pengraigddu -	1	1856,	9	9	—	—	—
81	Penpontbren - Penpontbren uchaf (see Leri).	8	1862,	100	334	76	—	42

CARDIGANSHIRE—continued.

No.	Name of Mine.	No. of Years worked.	Year of Greatest Output and Amount in Tons.		Total Output in Tons.			Average Output of Lead- ore in Tons.
					Lead- ore.	Blende.	Copper- ore.	
	Peerhiw (<i>see</i> Aberystwyth).							
	Penrhyngerwin (<i>see</i> Loveden).							
	Pensarn (<i>see</i> Brynarian).							
82	Penybanc -	5	1864,	64	199	—	—	40
83	Penycefn or Court Grange.	19	1851,	279	1,457	87	—	77
84	Plynlimon -	19	1874,	404	3,270	20	—	172
	Ponterwyd and Powell (<i>see</i> Llywernog).							
85	Pwll Roman -	1	1856,	2	2	—	9	—
86	Red Rock or Graiggoch.	27	1872,	243	3,282	25	—	121
87	Rheidol United	21	1856,	145	584	4,515	—	28
	Foxpath -	3	1855,	62	139	46	—	46
	Gothic -	3	1867 1868	17	41	—	—	14
	Erwtomau -	2	1916,	6	11	383	—	5
	Penclayen -	1	1853,	148	148	—	—	—
88	Silver Stream, Nantyrarian, or Blaendyff- ryn.	1	1882,	9	9	—	—	—
89	Swyddffynon -	1	1864,	4	4	—	—	—
90	Taliesin -	4	1855,	142	245	—	—	61
	Tanyralit (<i>see</i> Alltycrib).							
91	Temple -	1	1887,	3	3	20	—	—
92	Thomas United Tygwyn (<i>see</i> Mynach Vale).	2	1855,	42	75	19	—	37
93	Tyllwyd -	9	1856,	45	147	—	—	16
	Ty'nypwll (<i>see</i> Melindwr).							
	Vaughan (<i>see</i> Llettyhen).							
	Wemyss (<i>see</i> Frongoch W.).							
94	Ynys or Ynys- tudur.	2	1876,	5	9	—	—	4
95	Ystrad Einion -	2	1891,	5	9	10	45	4
96	Ystumtuen, Pen- rhiw and Ys- tumtuen.	19 8	1875, 1892,	175 55	816 233	9,795 581	— —	43 29
97	Sundry Mines -	—	—	—	744	115	—	—

ALPHABETICAL LIST OF MINES.

(Nos. 5, 14, 18, 24, 25, are not inserted in Map.)

MONTGOMERYSHIRE.

No.	Name of Mine.	No. of Years worked.	Year of Greatest Output and Amount in Tons.		Total Output in Tons.			Average Output of Lead-ore in Tons.
					Lead-ore.	Blende.	Copper-ore.	
1	Aberdaunant - Blaen Twymyn (see Dylife),	5	1875,	51	119	32	—	24
2	Brynposteg or Llanidloes. Bryntail (see Penyclun),	8	1868,	292	614	353	—	77
3	Brynyfedwen -	2	1857,	152	158	—	—	79
4	Cae Conroy or Tyisaf,	25	1867,	240	1,774	—	—	71
5	Cefnmaenllwyd	5	1858,	88	139	—	—	28
6	Ceulan -	20	1874,	26	260	—	—	13
7	Cwmbyr -	11	1874,	61	497	731	—	45
8	Cwmricket or Maesnant	4	1876,	6	16	1	—	4
9	Cwmfron -	3	1871,	20	33	144	—	11
10	Cwmfron E. -	3	1870,	32	72	105	—	24
11	Cyfarthfa or Nantddu. Dolminers (see Wye Valley).	4	1879,	50	99	—	28	25
12	Dyfnwgwm -	23	1862,	541	4,930	—	134	214
13	Dylife or Blaen Twymyn.	49	1862,	2,571	35,505	391	1,342	724
14	Fronfelen -	2	1848,	15	21	—	—	10
15	Geufron -	—	—	—	—	—	363	—
16	Gorn -	10	1850,	52	331	—	—	33
17	Llanerchyllt - Maesnant (see Cwmricket).	28	1869,	1,135	7,198	—	—	257
18	Moel Fadian - Nantddu (see Cyfarthfa).	—	—	—	—	—	25	—
19	Nantiago -	37	1875,	176	1,709	1,929	—	46
20	Nantmelyn -	5	1849,	30	59	—	43	12
21	Nanty - Nantygwrdd (see Wye Valley).	8	1863,	632	1,781	—	—	223
22	Nantyreira (see Snowbrook).	—	—	—	—	—	209	—
23	Nantyricket - Penyclun Van Consols - Bryntail -	11 12 23	1850, 1882, 1847,	776 283 158	1,805 1,661 1,821	— — —	— — —	164 138 79
24	Pearce's Llanid- loes.	1	1859,	2	2	—	—	—
25	Penyrallt -	1	1871,	10	10	—	—	—
26	Rhoswydol -	27	1869,	1,135	3,984	—	—	147
27	Siglenlas -	2	1868,	20	31	—	—	15

MONTGOMERYSHIRE—*continued.*

No.	Name of Mine.	No. of Years worked.	Year of Greatest Output and Amount in Tons.	Total Output in Tons.			Average Output of Lead- ore in Tons.
				Lead- ore.	Blende.	Copper- ore.	
28	Snowbrook or Nantyreira, Tyisaf (<i>see</i> Cae Conroy).	8	1880, 37	161	—	—	27
29	Van - -	51	1876, 6,850	96,739	28,424	—	1,897
30	Van E. - -	1	1880, 21	21	—	—	—
31	Wye Valley or Nantygwrdd and Dolminers.	13	1878, 425	2,265	446	—	174

LARGER MINES ARRANGED IN GEOGRAPHICAL ORDER FROM NORTH TO SOUTH.

SUMMARY OF OUTPUT OF CARDIGANSHIRE MINES.

(Mines with Output greater than 1,000 tons.)

	Lead-ore.	Lead.	Ratio.	Silver re-turned.	Silver esti-mated.	Silver per ton Ore.	Silver per ton Lead.	Blende.	Copper-ore.
	Tons.	Tons.		Oz.	Oz.	Oz.	Oz.	Tons.	Tons.
72. Loveden - - - - -	997	769	77.1	2,145	9,200	9.3	12.0	5	—
44. Esgairhir and Esgairfraith -	2,819	2,066	73.3	14,590	19,709	6.9	9.2	—	2,690
4. Allt-y-rib - - - - -	2,279 $\frac{3}{4}$	1,709 $\frac{1}{2}$	75.0	11,586	15,834	5.5-8.3 (av. 6).	7.5-11.3 (av. 8.5).	10	2 $\frac{3}{4}$
13. Bryn-y-rafr - - - - -	4,952	3,756	75.8	—	—	—	—	8,116	—
16. Bwlch-glas - - - - -	1,240	898	72.4	6,361	6,760	5.4	7.5	99	—
76. Mynydd-gorddu - - - - -	901 $\frac{1}{2}$	675 $\frac{1}{2}$	74.9	9,725	9,700	10.8	14.4	182 $\frac{3}{4}$	—
83. Pen-y-cefn - - - - -	1,457	1,059	73.0	17,124	40,000	27.6	37.8	87	—
9. Bron-floyd - - - - -	6,423	4,714	73.4	35,024	44,750	7.0	9.45	—	23 $\frac{1}{2}$
36. Daren E - - - - -	24,460	18,334	74.9	415,850	415,850	17.0	22.71	—	95 $\frac{3}{4}$
37. Daren S. - - - - -	9,248	6,869	74.3	173,527	241,300	27.5	36.1	196	1,047 $\frac{3}{4}$
35. Daren Great - - - - -	1,657 $\frac{3}{4}$	1,234 $\frac{1}{2}$	74.5	21,149	36,000	21.8	28.8	—	51 $\frac{3}{4}$
27. Cwmerfin - - - - -	9,919 $\frac{1}{4}$	7,240	73.0	182,594	196,000	19.9	26.9	36	60 $\frac{1}{2}$
52. Goginan :- - - - -	—	—	—	—	—	—	—	—	—
1837-44 - - - - -	7,851 $\frac{1}{4}$	5,324	—	—	—	—	3.0	—	—
1845-86 - - - - -	17,256 $\frac{3}{4}$	12,081 $\frac{1}{2}$	70.1	170,120	346,000	20.6	25.3	60	—
15. Bwlch - - - - -	7,750	5,699 $\frac{1}{2}$	73.5	74,784	104,200	13.5	18.2	6 $\frac{3}{4}$	—
25. Cwmbrwyno - - - - -	6,095	4,552 $\frac{1}{2}$	74.7	7,383	13,600	2.24	2.96	796	—
8. Bog - - - - -	1,542 $\frac{1}{4}$	1,082	70.1	4	3,160	2.0	3.0	702 $\frac{1}{2}$	—
70. Llywernog - - - - -	3,813 $\frac{3}{4}$	2,837	74.4	4,260	14,600	3.6	5.5	560 $\frac{1}{2}$	—
14. Bwadrain - - - - -	1,744	1,322 $\frac{1}{2}$	75.8	9,902	22,000	12.6	16.8	5	—

LARGER MINES ARRANGED IN GEOGRAPHICAL ORDER FROM NORTH TO SOUTH.

SUMMARY OF OUTPUT OF MONTGOMERYSHIRE MINES.

(Mines with Output greater than 1,000 tons.)

---	Lead-ore.	Lead.	Ratio.	Silver re- turned.	Silver esti- mated.	Silver per ton Ore.	Silver per ton Lead.	Blende.	Copper- Ore.
	Tons.	Tons		Oz.	Oz.	Oz.	Oz.	Tons.	Tons.
4. Cae Conroy	1,774	1,301	73.3	8,440	16,728	9.7	12.5	—	—
17. Llanerchynaur	7,198	5,493	76.3	36,423	40,203	5.6	7.3	—	—
26. Rhoswydol	3,984	3,022	75.1	4,560	12,569	3.2	4.3	—	—
7. Cwmbyr	497	376	75.6	218	1,160	2.4	3.0	731	—
13. Dylife	35,505	26,498	74.6	126,286	154,160	4.4	5.8	391	1,342
12. Dyfngwm	4,930	3,797	77.0	10,356	11,798	2.4	3.1	—	134
29. Van	96,739	75,400	77.9	756,142	771,557	7.8	10.3	28,424	—
23A. Penyclun	1,805	1,112	61.6	405	4,451	2.7	3.7	—	—
23A & B. Van Consols	1,661	1,262	75.9	2,864	5,307	3.2	4.2	—	—
23B. Bryntail	1,821	1,254	68.8	916	5,393	3.1	4.1	—	—
19. Nantiego	1,709	1,292	75.5	1,651	6,176	3.6	4.8	1,929	—
31. Wye Valley	2,265	1,747	77.1	6,458	7,850	3.9	4.9	446	—
21. Nanty	1,780	1,390	78.0	9,482	9,482	5.3	6.8	—	—
2. Brynposteg	614	456	74.2	—	—	—	—	353	—
Smaller mines	1,559	1,151	—	2,979	5,066	—	—	283	668

TABLE SHOWING AMOUNT AND PROPORTION OF DIFFERENT ORES
FROM THE VARIOUS FORMATIONS.

—	Van Forma- tion.	Gwestyn Forma- tion.	Gwestyn and Frongoch Forma- tions.	Frongoch Forma- tion.	Cwmyst- wyth Forma- tion.
Total lead-ore (in tons).	113,889	7,568	49,886	252,479	32,912
Total mixed ores (in tons).	153,117	11,093	58,336	334,974	51,837
Total number of mines returning ore.	16	15	6	95	1
Average lead-ore per mine (in tons).	7,118	506	8,311	2,658	—
Average mixed ore per mine (in tons).	9,500	740	9,731	3,526	—
Ratio of lead-ore to blende and copper-ore.	1,000/338/ 6·2.	1,000/80/ 386.	1,000/119/ 51·5.	1,000/325/2	1,000/576/0
Ratio of lead- and zinc-ores to copper-ore.	1,000/4·7	1,000/357	1,000/46	1,000/1·5	1,000/0
Silver in oz. per ton of lead-ore.	7·1	4·4	8·1	8·4	3·3
Total ore from larger mines (in tons).	151,429	9,392	58,271	323,955	51,837
Average mixed ore from each of larger mines (in tons).	18,930	2,348	14,570	9,256	—

INDEX.

- Abbey Consols mine, 128.
 Aberdaunant mine, 45, 167.
 Aberffrwd mine, 102, 129.
 Aberhosan, 152, 153.
 Abernant mine, 130.
 Aberystwyth, 1, 2.
 Aberystwyth grit, 2, 6.
 Aberystwyth mines, 96.
 Adit, *passim*, *see* especially Bwlch, 74, 80, 84; Frongoch, 105; Goginan, 76; Esgairhir, 50; Old Esgairlle, 92; Ystumtuen, 97.
 Afon Hengwm, 40, 153.
 Afon Hyddgen, 41.
 Air-shaft, Llanerchyrur, 151.
 Alderson's level, Cwmystwyth, 117.
 Alltddu lode, 102.
 Alltddu mine, *see* Rheidol United.
 Alltyerib mine, Talybont, 23, 53.
 Alltyerib North mine, 54.
 Alltyerib Wood, 23, 53, 54.
 Alma mine, *see* Llechweddhen, 144.
 Alnwick Castle Museum, 176.
 Ancient workings, Cwmystwyth, 32; Esgairlle, 94; Nantyricket, 175.
 Anticline, 7, 21, 27; Bryntail, 45; Brynrafr, 56; Cefnyresgair, 7; Cerig yr Hafan, 7; Cwmerfin, 75; Cwmsebon, 69; Eaglebrook, 137; East Daren, 66; Goginan, 78; Hafan, 141; Llanerchyrur, 151; Logaulas, 120; Loveden mine, 48; Mynyddygroes, 47; Nantiago, 163; Penyclun, 44; Plynlimon, 91; Plynlimon Cwm Biga, 7; Ysbytty Ystwyth, 33.
 Bacheiddon, 152; lode, 153.
 Bala formation, 2, 3.
 Balcombe's cross-cut, Bronfloyd, 63.
 Ball's shaft, Frongoch, 109.
 Bane Llechweddmaur, 41.
 Bane Rhoswydol, 36, 37, 152, 153.
 Bane Tyhen, 53.
 Barium-minerals, 45.
 Barracks, 49.
 Barren ground, Goginan, 77.
 Barton's cross-cut, Bronfloyd, 63.
 Barytes, Aberdaunant, 168; Bryntail, 45, 162; Gorn, 173; Penyclun, 161.
 Bastard lode, Van, 42.
 Belshazzar lode, Cwmystwyth, 116.
 Bidno, river, 175.
 Blaencennant mine, 130.
 Blaenculan, 9, 21; mine, 130.
 Blaenewm, Cwmystwyth, 32, 35; Cwmsymlog, 64.
 Blaen Cwmsymlog, 75.
 Blaendyffryn mine, *see* Silver Stream.
 Blaen Twymyn, *see* Dylife.
 Blende, *passim*; structure and conditions of formation, 183; relation to other minerals, 183, 184.
 Blende-lode, Caegynon, 29; Van, 43.
 Blue level, Copper Hill, Cwmystwyth, 117.
 Bodecoll mine, 131.
 Bog lode, 88, 89; mine, 87, 88.
 Bonsall's level, Copper Hill, Cwmystwyth, 117; Cwmystwyth, 113; Gelli'reirin, 139.
 Bontgoch, 59.
 Borth, 6.
 Boulder-clay, 33, 123.
 Boundary shaft, Frongoch, 109; Goginan, 77, 83.
 Bow Street Station, 59, 60, 62, 64, 69, 73, 143.
 Bradford shaft, Dylife, 39, 154.
 Bronberllan mine, *see* Abbey Consols.
 Bron Caradoc, 33.
 Bronfloyd, 26, 28; mine, 62.
 "Bron-y-Goch," *see* Frongoch.
 Brynarian mine, 131.
 Bryndyfi mine, 131.
 Brynglas lode, 89, 133; mine, 132.
 Bryn Llwyd, *see* Bronfloyd.
 Brynmawr, 7.
 Brynpica, 83; mine, 77; shaft, 83.
 Brynposteg mine, 166.
 Bryntail, 45, 161; mine, 45, 162.
 Brynyfedwen lode, 169; mine, 37, 168.
 Brynrafr mine, 4, 7, 9, 18, 24; description of, 55.
 Brynrywyn, 7.
 "Bucking stones," 94, 111.
 Bugeilyn Lake, 40.
 Burnett's Engine-shaft, Mynydd-gorddu, 59.
 Bushell, Sir Thomas, 62, 64.
 Bwadrain lode, 149; mine, 90.
 Bwadrain, South, 132.
 Bwlch coch, 152; lode 153.
 Bwlch Consols, *see* Bwlch.
 Bwlch Cwmerfin, *see* Bwlch.
 Bwlch Gwalter, 33.
 "Bwlch Kaniniog" lode, 24

- Bwlch mine, 74, 77, 79, 83.
 Bwlch United, *see* Bwlch.
 Bwlchglas, cross-courses, 9; lode, 15, 16, 24, 25; mine, 57.
 Bwlchgwyn mine, 29, 103; description of, 96.
 Bwlchgynt, 35, 136.
 Bwlchrhennaid mine, 79, 80, 81, 83.
 Bwlchystyllen, 27.
- Cae Conroy, lodes, 4, 5, 36, 37, 150, 151, 152; mine, 150.
 Caegynon, 102; lode, 29; mine, 99, 100.
 Caersws, 1, 157.
 Calcite, *passim*.
 Caledonian movements, 177.
 Cambrian mine, *see* Esgairhir.
 Cambrian Railway, 1.
 Cambrian South, *see* Camdwrbach.
 Camdwr lode, 26, 28, 40, 143; river, 24, 55.
 Camdwrbach mine, 132.
 Camdwrmaur mine, 26, 132.
 Camp Daren, 71.
 Capel Banhadlog, *see* Cwmfron East.
 Cape! Bethania, 23.
 Capel Nazareth, 53.
 Cardigan Consolidated mine, *see* Esgairhir.
 Cardiganshire group, 2.
 Carn Gwilym, 40.
 Caron mine, 133.
 Castell lode, 93, 94, 102, 130, 148; description of, 28; identified with Van lode, 47, 165.
 Castell mine, 94.
 Cefnabrwyno, 86.
 Cefngwyn mine, 26, 61, 133.
 Cefnmaenllwyd mine, 169.
 Cefnyresgair, 7.
 Cell river, 112.
 Central Wales, rock groups of, 3; structure of, 2.
 Cerig yr Hafan, 7, 24.
 Cerigyrwyn, 7; mine, 73, 134.
 Cerussite, 33, 38, 45, 61.
 Ceryst Valley, 157.
 Ceulan mine, near Dylife, 37, 169.
 Ceulan valley, Talybont, 21, 23, 150.
 Ceunant mine, 79, 82.
 Chalybite, 21, 22, 28, 46, 149, 173, 175.
 Child's shaft, Talybont, 23, 53.
 Clara mine, 133.
 Classification of formations, 3.
 Clay-joints, 8.
 Cleavage, 1, 3, 4, 8.
 Clywedog river and valley, 38, 39, 156, 162, 167, 172.
- Coed Dolfawr, 90.
 Comet lode, Cwmystwyth, 15-17, 30-32, 113, 117, 136; description of, 33, 35, 36.
 Company of Mine Adventurers, 51, 64, 80.
 Conglomerate, 4.
 Copa Hill, *see* Copper Hill.
 Copper Hill, Cwmystwyth, 16, 30, 31, 32, 113, 117, 175.
 Copper level, *see* Cwmdaren.
 "Copper-lode," Cwmystwyth, 116; Nantyricket, 175.
 Copper-ore, *passim*.
 Copper-pyrite, *passim*.
 Cors Fochno, 9.
 Costean pits, 67, 123.
 Counter-lode, East Daren, 67.
 Count Grange, *see* Penycefn.
 Craignant bach, *see* Bog.
 Craig y Llest, 35.
 Craig y Maes, 39.
 Craigypistyll, 27, 143.
 Creigiau Esgairfochnant, 5, 174.
 "Cripiau," 19.
 Cripiau bach, *see* Castell.
 Crosby's lode, Llywernog, 89.
 Cross-cut, *passim*, *see* especially Bronfloyd, 62; Brynpica, 84, 86; Bwlchglas, 25; Glogfach, 122; Goginan, 84; Rheidol United, 100; Van, 43, 159.
 Cross-courses, 8, 67; Bwlchglas, 58; Cwmerfin, 75; Esgairmwyn, 127; Glogfach, 10, 17, 121; Glogfawr, 10, 124, 142; Logaulas, 119; Nantiago, 163.
 Cross-road level, Cwmystwyth, 115.
 Cwmbwrwyno lode, 89, 90; mine, 86, 89.
 Cwmbyr mine, 153.
 Cwmdaren mine, 73, 134.
 Cwmerfin, 5, 66, 79; lode, 67, 74, 145; mine, 73.
 Cwmerfin West, *see* Melindwr Valley.
 Cwmergyr, 16, 28, 47.
 Cwmfron lode, 170; mine, 170.
 Cwmfron East, 171.
 Cwm Graig, 82.
 Cwm Leri lode, 23, 54.
 Cwmmaur mine, 134.
 Cwmnewyddion, 109.
 Cwmpryf mine, 135.
 Cwmrheidol mine, *see* Ystumtuen.
 Cwmricket mine, 171.
 Cwmsebon mine, 67, 134; description of, 69.
 Cwmsymlog, 27, 126; mine, *see* Daren, East.
 Cwmsymlog, North, 136.
 Cwmsymlog, West, 136.

- Cwm Tynant, 57.
 Cwmystwyth, 7, 15, 16, 17; early mineralisation, 178; formation, 3, 6, 34, 36; grits, 1, 2, 6, 7; lodes of, 30, 34; mine, 113.
 Cwmystwyth, South, 135.
 Cwmystwyth, West, 136.
 Cyfarthfa mine, 38, 40, 172, 183.
 Cyncoed, 139.
 Cyneiniog valley, 24.
 Cytiau'r Geifr, 37.
- Daren, 5, 71, 73; lode, 134, 145; mine, 62.
 Daren, East, 64, 75.
 Daren, South, *see* Cwmsebon mine.
 Davey's shaft, Glogfawr, 122, 124.
 "Deads," Van, 158.
 De Broke mine, *see* Dolwen.
 Deep adit, Ceunant, 82; Cwm Brwyno, 86; Dyfngwm, 156; Goginan, 77, 86; Gorn, 173; Grogwynion, 112; Llanerchyr, 151, 152; Llettyhen, 144; Logaulas, 118; Tyllwyd, 149; Ystumtuen, 97.
 Devil's Bridge, 5, 103, 105, 113, 130, 131.
 District lode, Bwlchglas, 24, 57, 58.
 Dolclettwr mine, 137, 148.
 Dolgelynen, 22.
 Dolminers mine, 165.
 Dolomite, 11, 30, 40, 117, 137, 172, 179.
 Doltwle, 34.
 Dolwen mine, 131, 136.
 Dovey Estuary, 7.
 Dovey River, 1.
 Drawing-shaft, Cwmerfin, 74.
 Drosgol hill, 4, 26, 40.
 Dyffryn Castell mine, *see* Castell.
 Dyfngwm, 14; lode, 38, 39, 155, 172; mine, 38, 155, 156.
 Dyfngwm-Dylife lode-belt, 26, 38, 40, 41, 156; splitting of, 39.
 Dylife, 5, 168, 169, 174; lode, 20; mine, 26, 39, 154.
- Eaglebrook lode, 132; mine, 137.
 East Daren, *see* Daren, East.
 East Glogfach shaft, 122.
 East shaft, Bwlchglas, 57.
 East Van, *see* Van, East.
 Eastern shaft, Bryntail, 162.
 Eddy's shaft, Logaulas, 118.
 Edwards' shaft, Van, 41, 157, 159.
 Eglwysnewydd Church, 32.
 Einion valley, 149.
 Eisteddfa, or Steddfa Gurig, 5, 91.
 Elan valley, 17.
 Elerch, 25, 59.
 Elgar mine, 26, 138.
 Ella mine, *see* Hendrefelen.
 Engine-shaft, Brynposteg, 167; Cae Conroy, 150; Castell, 95; Cwmerfin, 74; Cwmfron, 170; Esgairhir, 50; Frongoch, 105; Llywernog, 88; Nanty, 166; Van, 157, 160.
 Erfin valley (Cwmerfin), 69, 73.
 Erglodd (Eurglawdd) lodes, 22; mine, 22, 138.
 Erwtomau mine, *see* Rheidol United.
 Esgairgaed lode, Dylife, 39.
 Esgairfraith mine, 21, 22, 49, 50; description of, 52.
 Esgairhir lode, 14, 20, 21, 24, 130; mine, 49; south lode, 21.
 Esgairlle, 16, 92.
 Esgairlle West, *see* Castell.
 Esgairmwyn, 103; lode, 142; mine, 126; silver-content, 180.
 Evans, J. H., 34.
 Evans's lode, Bwlchglas, 11, 57.
- Fagwrfawr, 28.
 "False walls," 10.
 Fault, miner's usage of, 12.
 Fault-filling, 10.
 Faults, classification of, 8; characteristics of, 10, 11; north and south faults described, 8; east and west faults described, 10-13 and Chap. II.; width of, 10.
 Ffrwd yr Ydfran, 32.
 Finlayson, A. M., 178, 179.
 "Flat," Cwmystwyth, 31, 114.
 Flat-rod shaft, Logaulas, 118.
 Flats, Llanerchyr, 151; Van, 3, 18, 44, 157, 159.
 Florida mine, *see* Abbey Consols.
 Flucan, 11, 41, 43, 95, 158.
 Fodinae Regales, 64.
 Foel uchaf, 40.
 Folding-axes, direction of, 7.
 Folds, characteristics of, 7.
 Foster, C. le Neve, 41, 42, 158.
 Fossils, 2.
 Foxpath, *see* Rheidol United.
 Fox's lode, Cwmystwyth, 117.
 Francis, Absalom, 20, 21, 23, 26, 33, 61, 69, 71, 72, 77, 80, 82, 89, 127, 130, 133, 138, 139, 142, 147, 148, 149.
 Francis's level, Daren, 72; shaft, Goginan, 77.
 Fron, Cwmystwyth, 136.
 Fronfelen mine, 172.
 Frongoch, adit, 108; formation, *passim*; lode, 131; mine, 105.
 Frongoch, West, mine, 105, 109.

- Galena, *passim*.
 Gelli, *see* Gelli'reirin.
 Gelli'reirin mine, 139, 149.
 Geological Survey, horizontal sections, 1; maps, 1.
 Gertrude, *see* Bodecoll.
 Geufron, Rheidol valley, 102; Severn valley, 46, 173; Ysbytty Ystwyth, 33.
 Gilbertson's shaft, Goginan, 77, 78.
 Gill's higher level, Cwmystwyth, 31, 113; lower level, 113; lode, 116.
 Glandovey, 5, 12, 149; Castle, 9.
 Glangwen Wood, 44.
 Glanrheidol, 139.
 Glanville's shaft, Frongoch, 109.
 Glaslyn Lake, 174.
 Glogfach, cross-course, 10; lode, 33, 123; mine, 17, 120.
 Glogfawr, cross-course, 10; lode, 121; mine, 17, 123.
 Glyn mine, 45, 162.
 Gogerddan mines, *see* Bog and Daren.
 Goginan, 74, 79, 148; lode, 74, 79, 83, 139, 145; mine, 62, 66, 76.
 Goginan, West, 139.
 Gold, 117.
 Gorn mine, 173.
 Gossan, 11, 29, 33, 110, 131, 137.
 Gothic, *see* Rheidol United.
 Graigfawr, Cwmystwyth, 15, 30, 31.
 Graiggoch, Cwmystwyth, 34; Cwmnewydion, *see* Red Rock; Tyisaf, 37, 169.
 Graptolites, 2, 5.
 Gravel of glacial origin, Cwmystwyth, 34, 116.
 Great Daren, *see* Daren.
 "Great Flat," Cwmystwyth, 34.
 Great rock, Cwmystwyth, 30.
 Great West Van, *see* Esgairlle.
 Griffiths, W., 92.
 Grits, Aberystwyth, 1; Cwmystwyth, 1; Plynlimon, 1, 91; in Frongoch formation, East Daren, 66; near base of Frongoch formation, Ystrad Meurig, 5.
 Grogwynion mine, 108, 112.
 Grogwynion North mine, 140.
 Gwaithgoch lode, Rheidol valley, 101; mine, *see* Rheidol United.
 Gwaithgoch mine, Ystwyth valley, 108, 112; description of, 140.
 Gwaithyrafon, Cwmsymlog, 67, 73, 134.
 Gwestyn formation, *passim*; influence on lodes, 181, 185; number of mines in, 181; thickness of, 5; mine, 47.
 Gundry's engine-shaft, Bryntail, 162.
 Hade of lodes, 8, 10, 13-16.
 Hafan, 7; anticline, 25; quarries, 24, 57.
 Hafan lode, 14, 24, 26, 57, 58, 61, 133, 138, 146; throw of, 24.
 Hafan and Henfwlch mine, 4, 141.
 Hafodfeddgar, 46; lode, 46, 47.
 Hafren, or Severn river, 46.
 Halvans, 68.
 Harner, Edward, 161, 176.
 Heave of Castell lode, Caegynon, 99; Castell, 95; Penrhiw, 29.
 Hendrefelen, 33; mine, 141.
 Henfwlch mine, *see* Hafan and Henfwlch.
 "Hercynian" movements, 178.
 Hobson's shaft, Penpontbren, 23, 147.
 Home Office, plans in, 21, 35, 50, 61, 72, 79, 87, 99, 100, 129, 133, 139, 167.
 Hornstone, 42.
 "Horse," 11, 16, 31; Glogfawr, 126.
 Hyddgen, 40.
 Imperial, *see* Pantmawr.
 Implements, stone, Copper Hill, 32; Nantyricket, 175.
 Impregnation, 24.
 Incline, Goginan, 77.
 Intermediate adit, Grogwynion, 112.
 Intersection of lodes, 13, 93.
 Iron pyrite, 3, 4, 10, 30, 42, 46, 56, 98, 114, 173, 174, 183.
 Jackilas level, Cwmystwyth, 115.
 Jeremiah's stope, Cwmystwyth, 116.
 Joint-faults, 11.
 Joint-lode, 23, 36, 37.
 Joints, 11.
 Jones, O. T., 2, 9, 17, 34.
 Junction of lodes, Bwadrain, 90; Daren and Cwmsebon, 72, 76; Llanerchyr aur, 151; Llywernog, 89; Copper Hill, 32; Van, 159, 160.
 Keeping, W., 2.
 Kingside, Cwmystwyth, lode, 15, 16, 30, 31, 116; shaft, 34; workings, 113.
 King's level, Copper Hill, Cwmystwyth, 117.
 Labour costs, 186.
 Lapworth, H., 2.
 Leader, 19, 42.

- Lead-ore, *passim*; large blocks of, 61; masses of, in Ystwyth fault, 34.
- Lead-veins of Wales compared with Cornwall, 18.
- Leri mine, 142; river, 23, 54; valley, 25, 27.
- Level fawr, Cwmystwyth, 115; Glogfach, 120; Glogfawr, 123; Logaulas, 118.
- Level Gopor, *see* Cwmdaren.
- Level Newydd, adit, 81; lode, 80, 82; mine, 81, 83.
- Level y Coed, Daren, 72.
- Level y Nant, Grogwynion, 140.
- Lisburne mines, 105, 120, 122, 123, 185.
- Lisburne mines Development Syndicate, 124.
- Lisburne, New, mine, 142.
- Lisburne, South, mine, 127, 142.
- Llainhir mine, *see* Dolclettwr.
- Llanbadarn mine, 143.
- Llanbrynmair, 10.
- Llanfynyfelyn, 148; mine, 143.
- Llandovery formation, 3.
- Llandre station, 55, 57.
- Llanerch, 143.
- Llanerchyllau, 11; lode, 36, 37; mine, 4, 151.
- Llanfaircydogau mine, 126.
- Llangurig, 32, 175.
- Llanidloes, 1, 6, 157, 163, 165, 167, 170, 173.
- Llanidloes mine, *see* Brynposteg.
- Lawcwmbach, 27, 82; mine, 27, 143.
- Llawryglyn, 5.
- Llechwedd ddu lode, 39, 154; shaft, 155.
- Llechweddhelyg mine, 27, 144.
- Llechweddhen mine, 144.
- Llechweddmawr, 20, 21.
- Llethr cross-cut, 122.
- Llettyhen, or Lletty Evanhen mine, 27, 132, 144.
- Llettymarallt adit, 82.
- Llewernog, *see* Llywernog.
- Lloches y Lladron, 175.
- Lloyd's adit, Bronfloyd, 37; Cae Conroy, 150.
- Llwybr y Ceirw, 39.
- Llwynllwyd mine, *see* Lisburne, South.
- Llwynmalus mine, 145.
- Llwynteify mine, 29, 96.
- Llwynnwnch, *see* Frongoch.
- Llyfnant fault, 12, 17, 178; displacement of folds and strike-faults by, 17.
- Llyfnant valley, 9, 12, 20.
- Llywernog lode, 89; mine, 88.
- Lode, composite, 16; -filling, 179; mining, conception of, 10; splitting of, 13.
- Lodes, as faults, 12; displacement of, by faults, 16; how shown on map, 13; influence of country-rocks upon, 181; intersection of, 13; meeting of, 16; minerals in, 179; relation to east-and-west faults, 11; relation to igneous intrusions, 178; undulating course of, 14.
- Lodge Park, 9.
- Logaulas, 33; lode, 17, 33, 36, 135, 141; mine, 13, 118.
- Log y las, *see* Logaulas.
- Loss in dressing of ores, 51, 54, 185.
- Loveden mine, 4, 5, 7; description of, 48.
- Loveden shaft, East Daren, 65.
- Lower Llandovery formation, 2.
- Lower Silurian, 1, 3.
- Machynlleth, 1, 2, 5, 20.
- Mackworth, Sir Humphrey, 64, 80.
- Maenarthur Wood, 35.
- Maesnant, 47, 165; mine, *see* Cwmricket.
- Main shaft, Bwlchglas, 58.
- "Makes of ore," 37; Van, 159.
- Malachite, 46.
- Manganese-ore, 26, 40, 144.
- Manledd uchaf, 41.
- Marcasite, 10, 24, 29, 42, 56, 96, 98, 99, 133, 183.
- Melindwr mine, 75, 145; valley, 75, 76, 82.
- Merry's shaft, Bryntail, 45.
- Metalliferous Slate group, 2.
- Meyrick, Sir Samuel R., 18, 50, 64, 68, 71, 74, 77, 103, 105, 118, 126.
- Middle adit, Ceunant, 82; Llanerchyllau, 151.
- Middle level, Cwmystwyth, 113.
- Middle lode, Bronfloyd, 62; Bwlch, 80, 84; Esgairlle, 92.
- Middleton, Lady, 62.
- Middleton, Sir Hugh, 62, 64.
- Mills, W., Llanidloes, 91.
- Mine Adventurers, Company of, 51, 64, 80.
- Mineralization, 12.
- Minerals, association of, 182.
- Mineral Statistics, 68, 76, 78, 108, 111, 120, 122, 130, 137, 142, 148.
- Mitchell's level, Cwmystwyth, 31, 114.
- Mitchell's lode, Cwmystwyth, 16, 30, 31, 113, 114, 115.

- Moel Fadlan, 174.
 Moelglomen, 25, 146.
 Morgan's adit, Cae Conroy, 36.
 Morris, Lewis, 29, 126.
 Movements, in relation to mineral deposition, 184.
 Mynach river, 146.
 Mynach Vale mine, 131, 136, 146.
 Mynyddgorddu mine, 26, 59, 61.
 Mynyddygroes, 47.

 Nant Bwadrain, 132.
 Nant Cyff, 47.
 Nantddu mine, *see* Cyfarthfa.
 Nanteos and Nanteos Consols mine, *see* Aberystwyth mines.
 Nantfelen, *see* Nantmelyn.
 Nantglas, 147; lode, 101, 147; *see also* Rheidol United.
 Nantglas isaf adit, 101.
 Nantglas uchaf adit, 100.
 Nantlago mine, 9, 165, 171, 176; description of, 163.
 Nant Meirch, 28.
 Nantmelyn mine, 174.
 Nant Myherin, 103.
 Nant Silo, 27, 62.
 Nant Troedryesgair, 32.
 Nantycagal mine, *see* Eaglebrook.
 Nantyreiau mine, 103, 104.
 Nantyreiau, West. mine, 104.
 Nant y Fedw, 37.
 Nantygwrdd, *see* Wye Valley.
 Nant y mine, 166, 175.
 Nantymoch, 67.
 Nantyraber, 102.
 Nantyrarian lode, 89, 148.
 Nantyrarian mine, *see* Silver Stream.
 Nantyreira mine, 9, 163, 176.
 Nantyricket lode(s), 47, 171; mine, 4, 47, 174, 176.
 Nant yr Onen, 31.
 Neath, smelting of ores at, 51.
 Neuaddlwyd mine, *see* Bryndyfi.
 New Bog mine, Treddol, 147.
 New Castell mine, *see* Castell.
 New Level, *see* Level Newydd.
 New Lisburne mine, 142.
 New lode, *see* Fox's lode.
 Newmarsh adit, Brynrafr, 24.
 New Wye Valley, *see* Wye Valley.
 Normal faults, 8, 12, 17.
 North Cardigan mine, 54.
 North lode, Aberdaunant, 45, 168; Allt-y-erib, 53; Bronfloyd, 62; Bwlch, 80, 83, 86; Caegynon, 99; Cefngwyn, 133; Frongoch, 109; Glogfach, 122; Glogfawr, 123, 126; Llywernog, 88; Old Esgairlle, 92; Penyccfn, 61; Rhoswydol, 153.
 Ochre, Old Esgairlle, 93.
 Old Daren, *see* Daren.
 Old Esgairlle, *see* Esgairlle.
 Oliver's adit, Daren, 73.
 Ordovician System, 3.
 Ore-body(ies), form of, *see* individual mines; relation to anticlinal axes, 182; relation to country rocks, 66, 78, 156; relation to stratigraphical horizon, 180; relation to structure, 75, 151, 181, 182.
 Ore-deposition, relation to periods of earth movements, 179.
 Output, *see* individual mines *also* Plates XXIV. and XXVI.; decline of, 184.
 Overthrusts, 8; Llyfnant Valley, 9.

 Pantauhirion, *see* Grogwynion, North, 140.
 Pantmawr mine, 102, 147.
 Paull, W. H., 78.
 Pearce's Llanidloes, 175.
 Peat, 33.
 Penbontrhydybeddau, 69, 71.
 Penbwlch and Glogfawr adit, 124.
 Pencerig lode, Dylife, 39, 155.
 Penclayen, *see* Rheidol United.
 Pendre trial-shaft, Logaulas, 33.
 Pen Dylife, 38, 155.
 Pengeulan lode, Cwmystwyth, 116, 117, 135.
 Penglin, *see* Pengeulan.
 Pengraigddu, 82, 83; lode, 83; mine, 82.
 Pengrogwynion brook, 35.
 Penlanfach mine, 122, 123.
 Pennant valley, 36; fault in, 10.
 Penpare lode, Cwmystwyth, 136.
 Penpontbren lode(s), 22, 23; mine, 147.
 Penpontbren uchaf mine, *see* Leri.
 Penrhiw mine, 13, 29, 96.
 Penrhyncoch, 27.
 Penrhyngerwin mine, *see* Loveden.
 Pensarn, 9; mine, 131.
 Pentre Briwnant, 32, 34, 35, 136.
 Penybanc mine, 147.
 Penyccfn lode, 61; mine, 60; north lode, 26, 138.
 Penyclun, 45, 159; mine, 45, 157, 161, 162.
 Penygist lode, Logaulas, 141.
 Penyrallt, 175.
 Pettus, Sir John, 64, 71, 73.
 "Pipes," Esgairhir, 51.
 Pitch of folds, 7, 8, 24, 35; at Pontrhydygroes, 35; change of, 24; related to lodes, 178.
 Plum shaft, East Daren, 65.

- Plynlimon, 2, 4, 7; Cwm Biga, 7; grits, 2, 3; group of Sedgwick, 1; mine, 4, 18, 91, 164, 171; range, 20.
 Pont Dologau, 33.
 Ponterwyd, 2, 5, 26, 28, 87, 88; mines, 88.
 Pontrhydygroes, 5, 17, 35; lodes near, 34.
 Poole's mine, *see* Llywernog.
 "Porphyry" (grit), East Daren, 18, 66.
 Potter's ore, 42.
 Powell Consolidated, Powell's United and Powell's mine, *see* Llywernog.
 Price fixed for ore, 49.
 Price, *see* Pryse.
 Prices of ores, Esgairmwyn, etc., 126; also Plate XXV.
 Probert, J., 105.
 "Promise" of a lode, 12.
 Pryse, Sir Carberry, 49.
 Pryse's, level, Cwmerfin, 74, 75; shaft, East Daren, 65; Frongoch, 105; tunnel, Talybont, 53.
 Psilomelane, 26, 40.
 Pugh's shaft, Cwmystwyth, 30, 34, 113; workings, 113.
 Pumpsink lode, Cwmystwyth, 116.
 Pwll Roman, Treddol, 148.
 Pyromorphite, 38, 45, 61.

 Quartz, *passim*.
 Queen's level, Copper Hill, Cwmystwyth, 117.

 Raw's level, Cwmystwyth, 113.
 Red Rock mine, Cwmnewydion, 110.
 Reed's shaft, East Daren, 65.
 Rhanc y mynydd, Dylife, 39, 154.
 Rhayader, 2.
 Rheidol gorge, 148; river, 26, 29, 146; valley, 29, 90, 97, 99, 149; valley railway, 91.
 Rheidol United mines, 100.
 Rhiwrugos lode, *see* Rheidol United.
 Rhoswydol, 36, 152; lode, 168, 169; mine, 152.
 Rhydyronen, 22.
 River-work, *see* Gwaithyrafon.
 Roberts, John, 91.
 Roman adit, Cerigyrwyn, 73; level, Goginan, 76; work, Daren, 71.

 Sedgwick, A., 1.
 Severn river, 4, 46, 171, 174; valley, 46, 165, 173.

 Shales, near base of Frongoch formation, Cwmerfin, 75.
 Shatter-belt, 11, 36.
 Shoot, 182; Abbey Consols, 129; Cwmbrwyno, 87; Esgairraith, 52; Esgairmwyn, 126; Nantiago, 164; near junction of lodes, Llanerchyllur, 151; Mynydd-gorddu, 60; Rheidol United, 101.
 Siglenlas mine, 175.
 Silurian, 3.
 Silver, *see* individual mines; distribution of, 182.
 Silver-content, Esgairhir, 51; in relation to depth from surface, East Daren, 68; Esgairmwyn, 127.
 Silver Mountain, *see* Pantmawr.
 Silver Stream, 148.
 Simddelwyd lode, 132.
 Skinner's shaft, East Daren, 65, 66; Glogfach, 120.
 Slates, 8.
 "Slickensides," 42, 182; direction of, 11.
 Smith, Stanley, 176.
 Smith's lode, Llywernog, 89.
 Smyth, W. W., 12, 13, 17, 24, 34, 35, 68, 98, 118, 141.
 Snowbrook, *see* Nantyreira.
 Society of Mines Royal, 64, 71, 73, 76.
 "Soft ground," Cwmystwyth, 31, 34; Ystwyth fault, 31, 34, 136.
 Soft lode, Van, 41, 43.
 South Daren, *see* Cwmsebon.
 South lode, 160; Alltgerib, 53; Bronfloyd, 62; Bwlch, 80; Caegynon, 99; East Daren, 67; Glogfawr, 126; Llywernog, 88; Old Esgairlle, 93; Penyclun, 44; Van, 43, 157, 159, 160.
 "Stag," The, 90, 139.
 Staylittle, 23.
 Steddffa Gurig or Eisteddfa Gurig, 5, 91.
 Steel ore, 83, 144, 183.
 "Stockworks," 24.
 Strata Florida, 148.
 Striated rock-surface, 34.
 Strike-fault, 9, 16.
 Strings, 32.
 Stripe of ore, 12.
 Structure of the area, 6-19.
 Succession of minerals in lodes, 179; Van, 42.
 Sundry mines, 150.
 Swyddffynon mine, 148.
 Syncline, 6, 7, 32; East Daren, 66; Logaulas, 120; near Hafan, 24; Upper Ystwyth, 6; Van, 159.

- Taliesin, 9, 148.
 Talybont, 4, 23; district, 22, 23, 24, 53, 54, 147.
 Tanyrallt mine, Talybont, 23, 54.
 Tarannon, 2, 10; formation, 6.
 Tarenig river, 47; valley, 28.
 Taylor's level, Copper Hill, Cwmystwyth, 117.
 Taylor & Co., mines worked by;
 Cwmbrwyno, 86; Cwmerfin, 74;
 Cwmystwyth, 115; East Daren, 65; Frongoch, 105, 106, 108;
 West Frongoch and Wemyss, 109;
 Glogfach, 122; Glogfawr, 123;
 Goginan, 77; Gwaithgoch, 140;
 Logaulas, 118; Red Rock, 110.
 Taylor's shaft, Cwmbrwyno, 86;
 Cwmerfin, 74; Cwmystwyth, 115;
 East Daren, 65; Frongoch, 105, 106, 108; Glogfach, 122; Goginan, 77; Logaulas, 118.
 Teifi valley, 6.
 Temple mine, 29, 148.
 Tertiary period, 178.
 Thickness, Cwmystwyth formation, 6; Gwestyn formation, 5; rocks within the area, 2; Van formation, 4; *see also* Plate I.
 Thieves Den, 175.
 Thomas, T. P., 149.
 Thomas United, *see* Cwmsebon.
 Top adit, Cwmystwyth, 115.
 Towy valley, 6.
 Treddol, 5, 149.
 Tregaron, 6; hills east of, 1.
 Trial-adits, Glangwden Wood, 44.
 "Tumblers" of lead-ore, 138.
 Twymyn valley, 150, 168, 169.
 Tygwyn, *see* Mynach Vale.
 Tyisaf, Llanbrynmair, 4, 36, 150; lode, 37, 169; mine, 5, 36, 37; *see also* Cae Conroy and Llanerchyrur.
 Tyllwyd mine, 149.
 Tylweh, 1, 167, 170.
 Tynewydd, 25.
 Tynyfron, 29, 98; adits, 29; mine, 97.
 Ty'nyppwll stream, 146; mine, *see* Melindwr valley.
 Underlie, 10.
 Upper adit, Ceunant, 82.
 Upper level, Daren, 72.
 Van, 3, 4, 5, 7, 41, 161; "flats," 161; lode, 4, 16, 18, 41, 42, 43, 44, 46, 47, 91, 157, 159, 161, 162, 165, 167, 171, 173; mine, 3, 5, 18, 44, 157, 161.
 Van Consols, *see* Penyclun.
 Van formation, *passim*; number of mines in, 181; thickness of, 4.
 Van, East, mine, 5, 43, 177.
 Vaughan mine, *see* Llettyhen.
 Vaughan's shaft, Frongoch, 105; Logaulas, 118.
 Vughs, 31, 114, 127.
 Walker's lode, Blaenceulan, 21.
 Waller, W., 20, 24, 49, 51, 64, 74, 76, 79, 82.
 Water, Brynposteg, 167; Esgair-mwyn, 127; -power, 56, 104, 186.
 Weathering of Gwestyn rocks, 4.
 Welsh Potosi, 49, 52.
 Wemyss mine, *see* Frongoch West.
 Wenlock, 6.
 Western Engine-shaft, Bryntail, 162; Goginan, 77.
 Western shaft, Brynpica, 77.
 West Imperial, *see* Geufron, Rheidol Valley.
 "West joint," Cwmystwyth, 115.
 West Nanty, *see* Nantygwrddy and Wye Valley.
 West shaft, Bwlchglas, 57.
 West Wye Valley or Dolminers, *see* Wye Valley mines.
 Whim shaft, Cwmerfin, 74.
 Whimsey shaft, Esgairhir, 50.
 Wilkin's level, Alltyerib, 53, 54.
 Williams, Sir Hugh, 176.
 Williams, John, 127.
 William's level, Cwmerfin, 74.
 Willow Bank mine, *see* Llechwedd-helyg.
 Witherite, 45; Aberdaunant, 168; Bryntail, 162; Gorn, 173.
 Worsley's shaft, Logaulas, 33.
 Wye river, 166; valley, 47, 165.
 Wye Valley mines, 4, 47, 165.
 Ynys, 149.
 Ynystudur, *see* Ynys.
 Yr Allt, Ystwyth valley, 35.
 Ysbytty Cyfnyn, 148.
 Ysbytty Ystwyth, 33.
 Ystrad Einion mine, 149.
 Ystrad Meurig, 5.
 Ystumtuen, 29, 96, 99, 102; mine, 97.
 Ystwyth fault, 12, 17, 31, 33, 35, 36, 116, 135, 136, 178; throw of, 17, 34-36.
 Ystwyth river, 5; valley, 32.

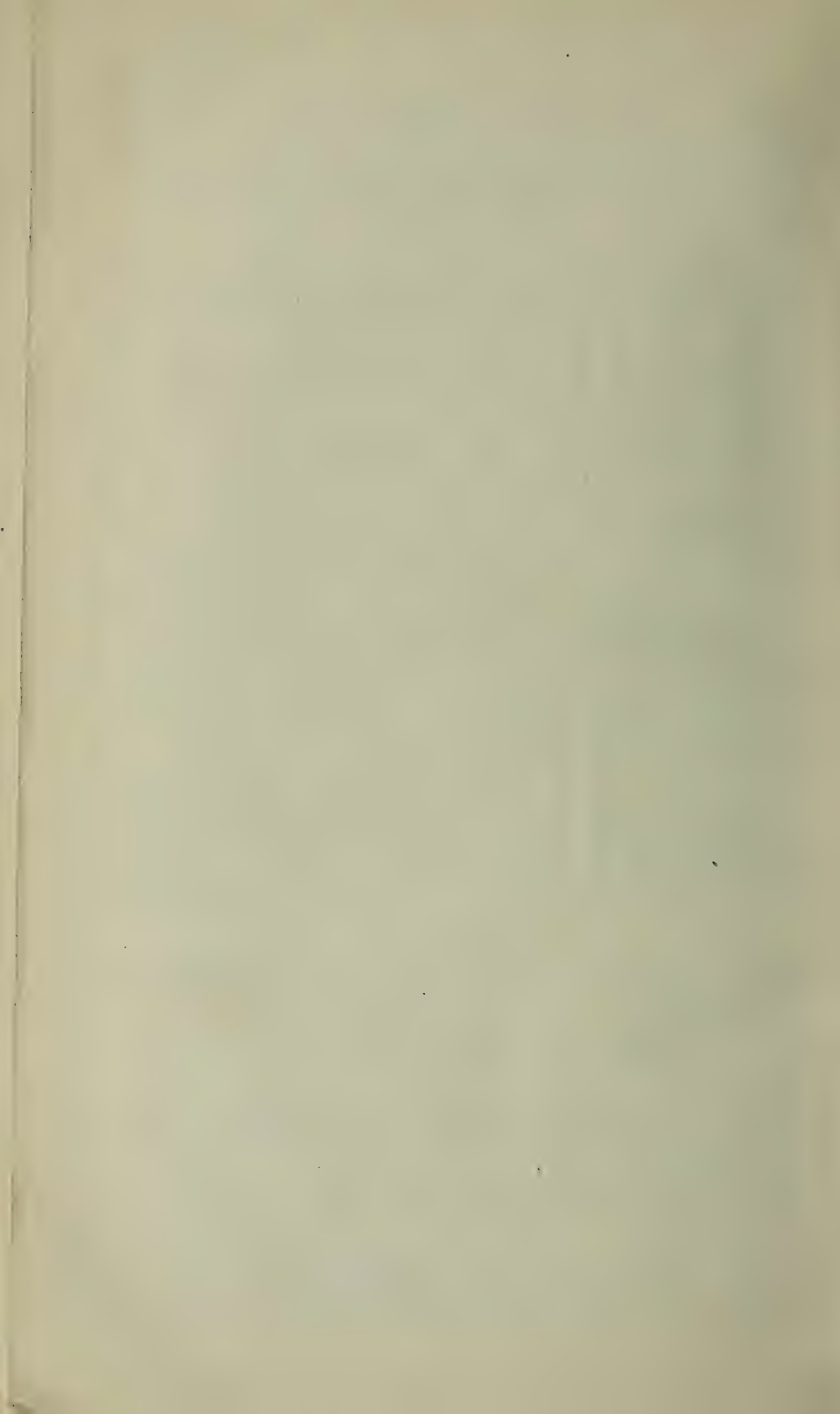
SPECIAL REPORTS ON THE MINERAL RESOURCES OF
GREAT BRITAIN.

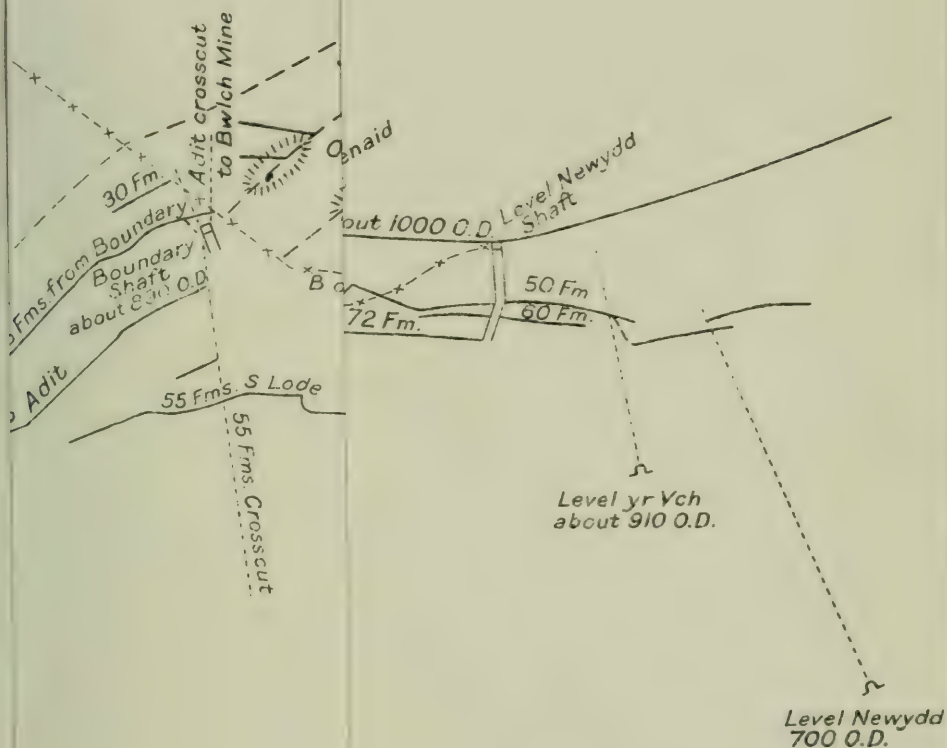
VOL. I. TUNGSTEN AND MANGANESE ORES. By H. Dewey and C. E. N. Bromehead, B.A., with contributions by T. Eastwood, A.R.C.S., G. V. Wilson, B.Sc., and R. W. Pocock, B.Sc. 59 pp. 2 illustrations. Wrapper (1915; Edit. 3, <i>in preparation</i>)	s. d.
VOL. II. BARYTES AND WITHERITE. By G. V. Wilson, B.Sc., T. Eastwood, A.R.C.S., R. W. Pocock, B.Sc., D. A. Wray, M.Sc., and T. Robertson, B.Sc., with contributions by H. G. Dines, A.R.S.M. 119 pp. 6 plates. 1 text figure. (1915; Edit. 3, 1922)	3 0
VOL. III. GYPSUM AND ANHYDRITE. By R. L. Sherlock, D.Sc., and B. Smith, M.A.; AND CELESTINE AND STRONTIANITE. By R. L. Sherlock, D.Sc. 64 pp. 4 illustrations. Wrapper. (1915; Edit. 2, 1918)	2 0
VOL. IV. FLUORSPAR. By R. G. Cartuthers, R. W. Pocock, B.Sc., and D. A. Wray, B.Sc., with contributions by H. Dewey, and C. E. N. Bromehead, B.A. 39 pp. 2 illustrations. Wrapper - - - (1916; Edit. 2, 1917)	0 9
VOL. V. POTASH-FELSPAR, PHOSPHATE OF LIME, ALUM SHALES, PLUMBAGO OR GRAPHITE, MOLYBDENITE, CHROMITE, TALC AND STEATITE (SOAPSTONE, SOAP-ROCK AND POTSTONE), DIATOMITE. By A. Strahan, Sc.D., LL.D., F.R.S.; J. S. Flett, D.Sc., LL.D., F.R.S.; and C. H. Dinham, B.A., with contributions by C. T. Clough, M.A.; T. Eastwood, A.R.C.S.; and A. F. Hallimond, B.A. 43 pp. 3 illustrations. Wrapper. (1916; Edit. 2, 1917)	1 0
VOL. VI. REFRACTORY MATERIALS: GANISTER AND SILICA ROCK, SAND FOR OPEN-HEARTH STEEL FURNACES, DOLOMITE. RESOURCES AND GEOLOGY. 241 pp. 3 plates. 8 text figures. Wrapper - - - (1918; Edit. 2, 1920)	7 6
VOL. VII. MINERAL OIL, KIMMERIDGE OIL SHALE, LIGNITES, JETS, CANNEL COALS, NATURAL GAS. ENGLAND AND WALES. By Sir A. Strahan, K.B.E., Sc.D., LL.D., F.R.S.; with contributions by W. Gibson, D.Sc.; H. Dewey; B. Smith, M.A.; C. E. N. Bromehead, B.A.; J. Pringle. 125 pp. 1 plate. 7 text figures. Wrapper - - - (1918; Edit. 2, 1920)	5 0
VOL. VIII. Iron Ores: HEMATITES OF WEST CUMBERLAND, LANCASHIRE AND THE LAKE DISTRICT. By B. Smith, M.A. 182 pp. 4 plates. 29 text figures. Wrapper - - - (1919)	9 0
VOL. IX. IRON ORES (<i>contd.</i>). SUNDRY UNBEDDED ORES OF DURHAM, EAST CUMBERLAND, NORTH WALES, DERBYSHIRE, THE ISLE OF MAN, BRISTOL DISTRICT AND SOMERSET, DEVON AND CORNWALL. By T. C. Cantrill, B.Sc., R. L. Sherlock, D.Sc., and H. Dewey. 87 pp. 7 text figures. Wrapper - - - (1919)	3 6
VOL. X. IRON ORES (<i>contd.</i>). THE HEMATITES OF THE FOREST OF DEAN AND SOUTH WALES. By T. F. Sibly, D.Sc. 93 pp. 14 text figures. Wrapper - - - (1919)	4 0
VOL. XI. IRON ORES (<i>contd.</i>). THE IRON ORES OF SCOTLAND. By M. Macgregor, B.Sc.; G. W. Lee, D.Sc.; G. V. Wilson, B.Sc.; with contributions by T. Robertson, B.Sc., and J. S. Flett, F.R.S. 240 pp. 18 text figures - - - (1920)	10 0
VOL. XII. IRON ORES (<i>contd.</i>). BEDDED ORES OF THE LIAS, OOLITES AND LATER FORMATIONS IN ENGLAND. By G. W. Lamplugh, F.R.S., C.B. Wedd, B.A., and J. Pringle. 240 pp. 8 plates. 12 text figures. Wrapper - - - (1920)	12 6

VOL. XIII. IRON ORES (<i>contd.</i>). PRE-CARBONIFEROUS AND CARBONIFEROUS BEDDED ORES OF ENGLAND AND WALES. By Sir A. Strahan, K.B.E., Sc.D., LL.D., F.R.S.; W. Gibson, D.Sc.; T. C. Cantrill, B.Sc.; R. L. Sherlock, D.Sc., and Henry Dewey. 123 pp. 3 plates. 10 text figures. Wrapper (1920)	s. d. 7 6
VOL. XIV. REFRACTORY MATERIALS: FIRECLAYS. RESOURCES AND GEOLOGY. 243 pp. 4 plates. 13 text figures. Wrapper (1920)	8 0
VOL. XV. ARSENIC AND ANTIMONY ORES. By Henry Dewey, with contributions by J. S. Flett, O.B.E., LL.D., D.Sc., F.R.S., and G. V. Wilson, B.Sc. 59 pp. 1 plate. 2 text figures. Wrapper - - - (1920)	3 0
VOL. XVI. REFRACTORY MATERIALS: GANISTER AND SILICA-ROCK, SAND FOR OPEN-HEARTH STEEL FURNACES, DOLOMITE. PETROGRAPHY AND CHEMISTRY. By Herbert H. Thomas, M.A., Sc.D., A. F. Hallimond, M.A., and Ernest G. Radley. 115 pp. 7 plates. 6 text figures. Wrapper - - - (1920)	5 0
VOL. XVII. THE LEAD, ZINC, COPPER AND NICKEL ORES OF SCOTLAND. By G. V. Wilson, B.Sc., with contributions by John S. Flett, LL.D., F.R.S. 159 pp. 2 plates. 16 text figures - - - (1921)	7 6
VOL. XVIII. ROCK-SALT AND BRINE. By R. L. Sherlock, D.Sc. 123 pp. 2 plates. 16 text figures. Wrapper - - (1921)	5 0
VOL. XIX. LEAD AND ZINC ORES IN THE CARBONIFEROUS ROCKS OF NORTH WALES. By Bernard Smith, M.A. 162 pp. 3 plates. 25 text figures. Wrapper - - - (1921)	5 6
VOL. XX. LEAD AND ZINC: THE MINING DISTRICT OF NORTH CARDIGANSHIRE AND WEST MONTGOMERYSHIRE. By O. T. Jones, M.A., D.Sc. 207 pp. 1 map. 27 plates. 4 text figures. Wrapper - - - (1922)	7 0
VOL. XXI. LEAD, SILVER-LEAD AND ZINC ORES OF CORNWALL, DEVON AND SOMERSET. By Henry Dewey. 72 pp. 4 plates. 14 text figures. Wrapper - - - (1921)	2 6
VOL. XXII. LEAD AND ZINC ORES OF THE LAKE DISTRICT. By T. Eastwood, A.R.C.S. 56 pp. 1 plate. 4 text figures. Wrapper - - - (1921)	2 0
VOL. XXIII. LEAD AND ZINC ORES IN THE PRE-CARBONIFEROUS ROCKS OF WEST SHROPSHIRE AND NORTH WALES. PART I.—WEST SHROPSHIRE, by Bernard Smith, M.A. PART II.—NORTH WALES, by Henry Dewey and Bernard Smith, M.A. 95 pp. 13 text figures. Wrapper - - - (1922)	3 0

In Preparation.

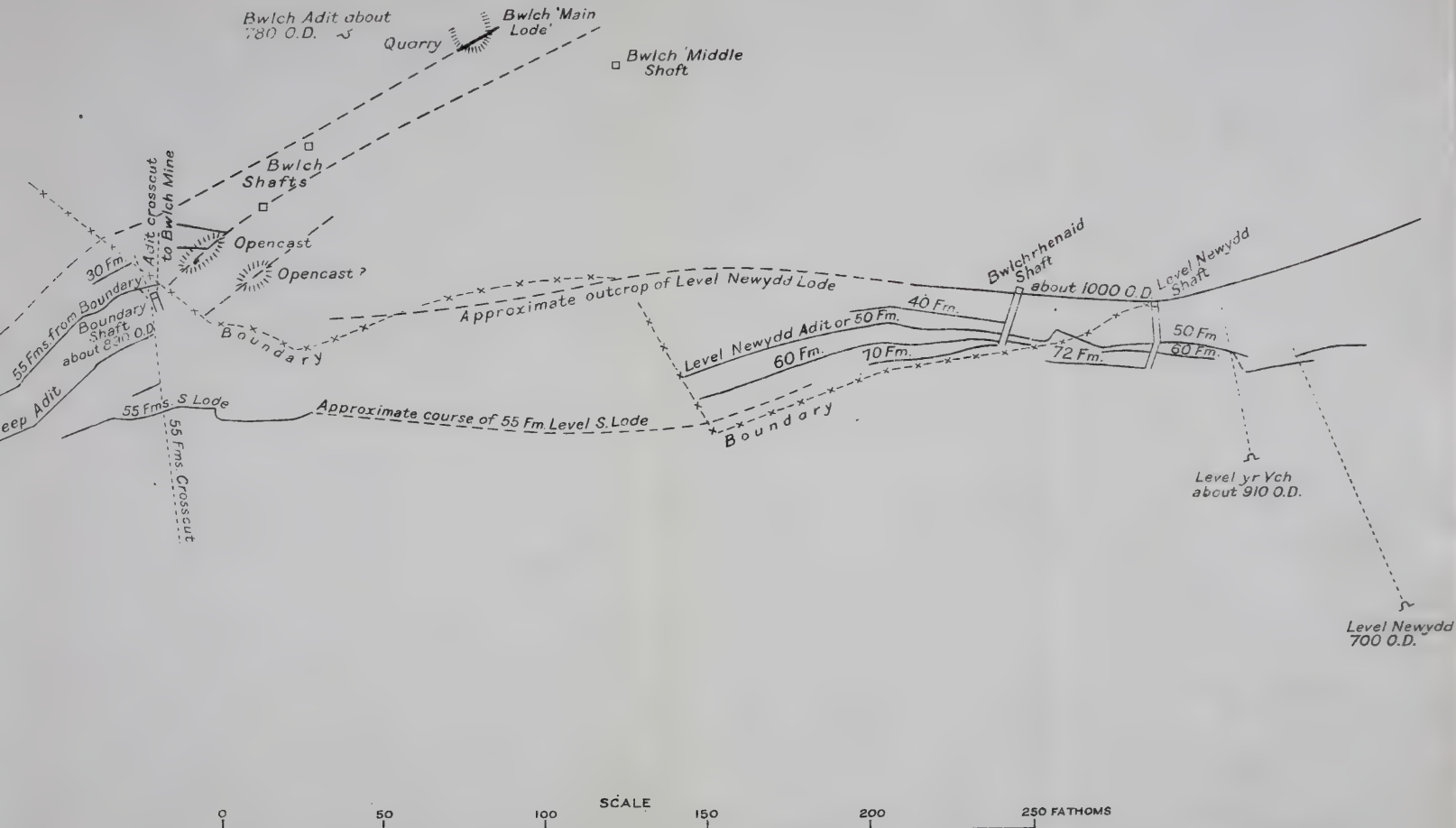
VOL. . LEAD AND ZINC ORES OF THE PENNINES. Part. I.—NORTHUMBERLAND AND ALSTON MOOR. By Stanley Smith, B.A., D.Sc.	
VOL. . LEAD AND ZINC ORES OF THE PENNINES. Part. II.—YORKSHIRE, ETC. By R. G. Carruthers.	
VOL. . COPPER ORES OF THE WEST OF ENGLAND. By Henry Dewey.	
VOL. . COPPER ORES OF THE MIDLANDS, THE LAKE DISTRICT, AND NORTH WALES. By Henry Dewey, and others.	
VOL. . REFRACTORY MATERIALS: FIRECLAYS. CHEMISTRY AND PHYSICAL TESTS, By F. R. Ennos, B.A., and other contributors.	
VOL. . MINERAL OIL, CANNEL COALS, ETC., OF SCOTLAND.	







RELATION OF GOGINAN, BWLCH AND LEVEL M



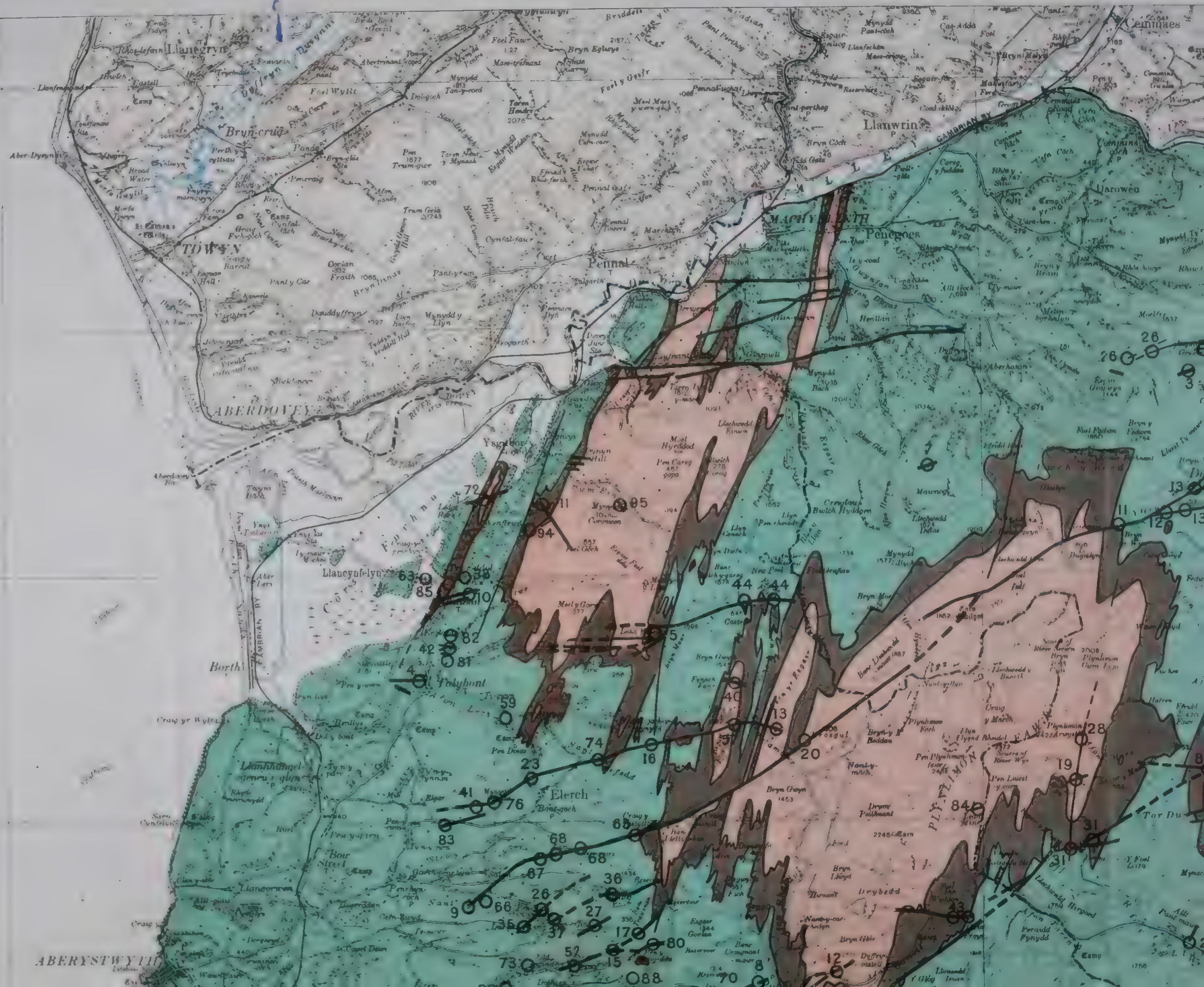
GOGINAN, BWLCH AND LEVEL NEWYDD LODES.

SPECIAL REPORTS,

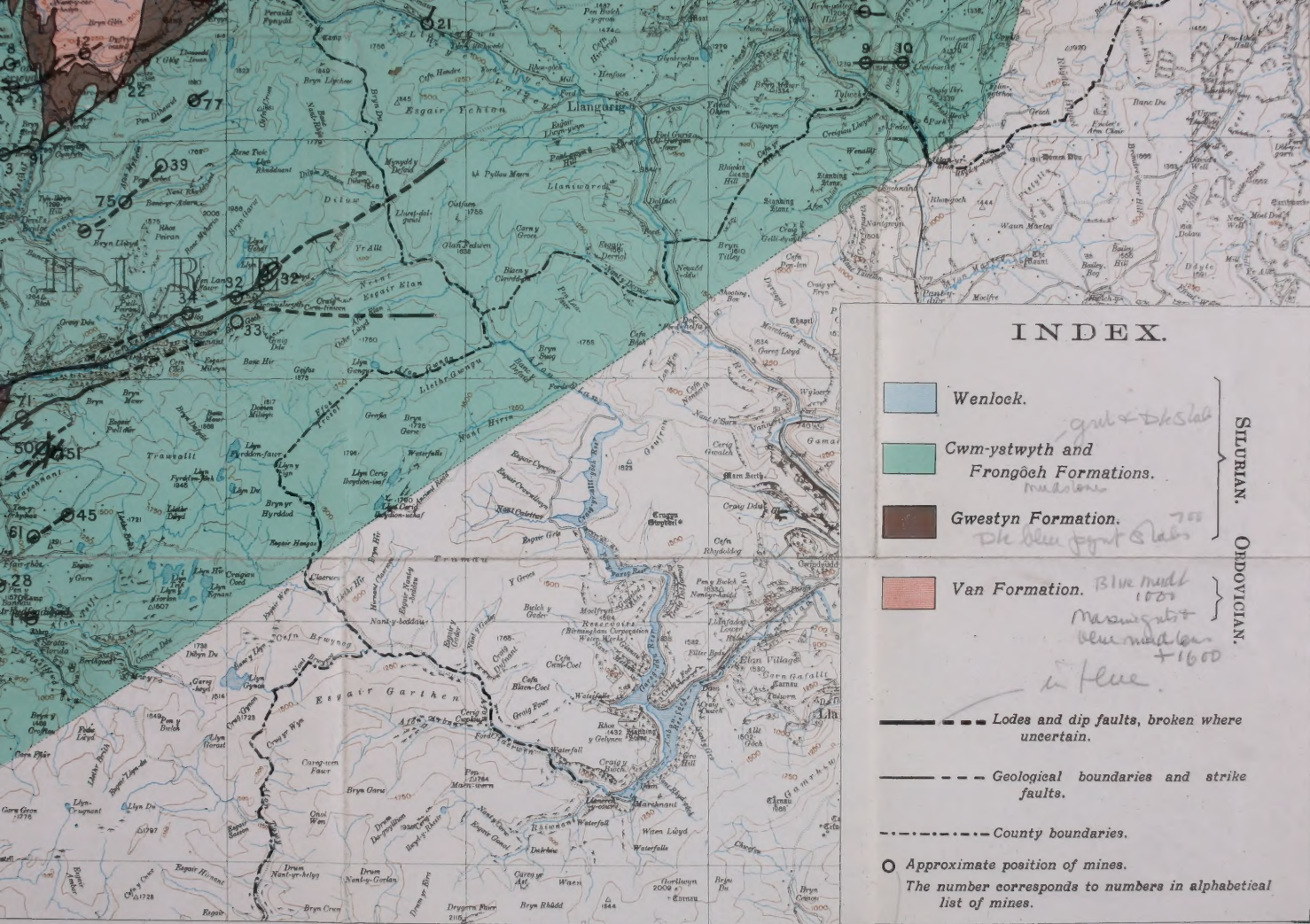


les to One Inch - 1882

THE MINING
AND WEST 1







Scale of Two Miles to One Inch - 126728

Ordinance Survey 1891

GEOLOGICAL MAP OF THE MINING DISTRICT OF
RDGANSHIRE AND WEST MONTGOMERYSHIRE.

Small black dot

78

SERIAL

